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The University of Adelaide

REPORT

OF THE

WAITE AGRICULTURAL RESEARCH INSTITUTE

SOUTH AUSTRALIA

AND ASSOCIATED ACTIVITIES OF THE

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

1950-1951

ADELAIDE
AT THE HASSELL PRESS
1953

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21 DEC 1953

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AND ASSOCIATED ACTIVITIES
OF THE COMMONWEALTH SCIENTIFIC AND
INDUSTRIAL RESEARCH ORGANIZATION

THE LABORATORIES OF THE WAITE AGRICULTURAL RESEARCH INSTITUTE.

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The University of Adelaide

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His Excellency the Governor.

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A. W. Bampton, A.I.A.S.A., REGISTRAR.

The Waite Agricultural Research Institute

STAFF (at 31st December, 1951)

Director: J. A. Prescott, C.B.E., D.Sc., F.R.S.

Agricultural Chemistry:

Head of Department and Waite Professor of Agricultural Chemistry: J. A. Prescott, C.B.E., D.Sc., F.R.S.
Senior Soil Chemist: C. S. Piper, D.Sc.
Lecturer in Agricultural Chemistry: R. J. Best, D.Sc.
Chemists: H. P. C. Gallus, M.Sc., A. G. Tyson, B.Sc., D. G. Lewis, B.Sc.
Research Scholar: J. S. Kanwar,† M.Sc. (Agr.).
Technical Assistant: J. Strokowsky.
Laboratory Assistant: R. D. Bond.

Agronomy and Agrostology:

Head of Department and Waite Professor of Agronomy: H. C. Trumble, M.Ag.Sc., D.Sc.
Chief Assistant in Agronomy: K. Woodroffe, B.Ag.Sc.
Assistant Agronomists: D. R. Bathe, M.Sc. (Agr.), D. E. Symon, B.Ag.Sc.
Research Fellows: C. R. Kleinig, B.Ag.Sc., B. A. Roark, B.Sc.
Systematic Botanist: Enid L. Robertson, B.Sc. (part time).
Technical Assistants: E. J. Leaney, R. M. Feuerheerdt.
Laboratory Assistants: Naomi M. Nugent, Margaret E. Jackman, J. Wendy Banfield, Lynette A. Edwardes.
Overseer at Yudnapinna Field Station: C. H. J. Phillips.

Genetics and Plant Breeding:

Head of Department and Professor of Genetics: D. G. Catcheside, M.A., D.Sc., F.R.S.
Geneticist: A. T. Pugsley, B.Ag.Sc., M.Sc.
Assistant Geneticist: G. M. E. Mayo, B.Ag.Sc.
Cytologist: K. Abele, M.A., Ph.D.
Plant Breeder: B. Horowitz,* Eng. Agr.D.Ag.Sc.
Technical Assistants: D. O. Axarlis, R. W. Mallen.
Laboratory Assistant: Geraldine E. Brookes.
Research Scholar: H. N. S. Ambastha,† B.Sc.

Entomology:

Head of Department: D. C. Swan, M.Sc.
Entomologists: H. G. Andrewartha, D.Sc., T. O. Browning, B.Sc., Ph.D., H. F. Lower.
Research Fellow: P. E. Madge, M.Sc.Agr.
Research Scholar: A. S. Atwal,† B.Sc.
Research Assistant: Ann Manchester, B.Sc.Agr.
Technical Assistant: Helen M. Brookes.
Laboratory Assistant: Margaret E. Morphett, Colleen M. Hill.

* Seconded by C.S.I.R.O.
† Commonwealth Technical Co-operation Scheme (Colombo Plan).

PLANT PATHOLOGY:

Head of Department: C. G. HANSFORD, M.A., Sc.D.
Senior Plant Pathologist: N. T. FLENTJE, M.Sc., Ph.D.
Senior Microbiologist: J. H. WARCUP, M.Sc., Ph.D.
Plant Pathologists: A. KERR, B.Sc., N. C. CROWLEY, B.Ag.Sc.
Junior Research Scholar: MARGARET W. LOUTIT, B.Sc.
Research Scholar: H. K. SAKSENA, M.Sc.
Technical Assistant: S. R. HOCKLEY.
Laboratory Assistants: JANET E. THOMSON, JOYCE MUXLOW, LEA WICHMAN.

PLANT PHYSIOLOGY:

Senior Plant Physiologist: F. L. MILTHORPE, M.Sc.Agr., Ph.D.
Laboratory Assistant: MAUREEN T. WHITE.
Plant Physiologists: N. G. MARINOS, B.A., M.Sc. (Temp.), L. H. MAY, B.Sc. (on leave).

CLERICAL STAFF (for Waite Institute and C.S.I.R.O.):

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Clerk*: F. W. BLANKSBY.
Librarian: JEAN SUSMAN, B.Sc.
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PHOTOGRAPHER: K. P. PHILLIPS, A.R.P.S.; Assistant: BEATRICE E. WINTER.

Research Assistant in Climatology: JOYCE A. COLLINS, B.Sc.

FARM:

Manager: K. A. PIKE, R.D.A.
Foreman: A. W. DICK.

MEMBERS OF THE STAFF WHO WERE ABSENT ON STUDY LEAVE DURING 1950 OR 1951:

R. J. BEST, N. T. FLENTJE, D. C. SWAN.

TEMPORARY AND VOLUNTARY WORKERS DURING 1950 AND 1951:

J. A. ZWAR, M. V. CARTER, DENISE WILLIAMS, H. E. MANSBRIDGE, R. W. JESSUP, L. G. SEMMENS, B. W. HOLLOWAY.

MEMBERS OF THE STAFF WHO HAVE LEFT FOR OTHER APPOINTMENTS SINCE 1ST JANUARY, 1950:

R. L. CROCKER, A. J. K. WALKER, N. S. TIVER, P. F. BUTLER, CONSTANCE M. EARDLEY, MARY A. TODD, HELEN M. FERRES.

VISITORS:

DR. H. L. PENMAN, of Rothamsted Experimental Station. October, 1951, to April, 1952. Nuffield Foundation.
DR. E. R. GRAHAM, of Missouri University. August, 1951, to May, 1952. Fulbright Scholar.

*Appointed by C.S.I.R.O.

The Waite Agricultural Research Institute

1. Introduction.

The foundation of the Waite Institute was made possible as a result of the gift of Peter Waite to the University of Adelaide of land and property at Glen Osmond, together with an endowment.

The land comprises the Netherby Estate (112 acres) and Claremont (53 acres) adjoining the main estate of Urrbrae, making a total of 299 acres as the original gift to the University for the Institute, in addition to 114 acres to the South Australian Government for an Agricultural High School. The University has since purchased 80 acres of the Springfield estate adjacent to Netherby and 10 acres of Alverstoke for the purposes of the Institute.

Including investments to the value of £58,450, the total value of the gift was estimated at £100,000; the annual Government subsidy of five per cent. amounted to £5,000, and work began with an income of about £8,000.

The first appointments to the staff were made in 1924 and 1925.

The first three laboratories were those endowed by the late Sir John Melrose, the family of the late John Darling, and the family of the late Ranson Mortlock. A fourth laboratory was completed in 1947.

In addition to the laboratories, a range of glasshouses, two implement sheds, a woolshed and a cereal barn have been erected since 1925.

Endowments subsequent to the original one of Peter Waite have included those of the late Mrs. Elizabeth Macmeikan, Mr. Hugh Hughes, Mr. W. D. Grigg, and Mr. W. H. Sandland. The Ranson Mortlock Trust Fund was established in 1936 by the family of the late Mr. Frederick Ranson Mortlock for research in connection with the management of pastoral lands in the more arid regions. Mr. J. T. Mortlock subsequently generously supported these investigations and on his death in 1950 made financial provision for their continuation.

Apart from its original and subsequent endowments, the Institute derives its main income from appropriations under Acts of Parliament of South Australia.

Since 1927 the Division of Biochemistry and General Nutrition of the Commonwealth Scientific and Industrial Research Organization has maintained at the Waite Institute a field station equipped with feeding pens for the nutrition of sheep under experimental conditions.

Since 1929 the Waite Institute has been the headquarters of the Division of Soils and since 1935 has housed the Oenological Research Unit of the Commonwealth Scientific and Industrial Research Organization.

For the years 1950 and 1951 under review a total sum of £13,670 was received from the Wool Research Trust Account of the Commonwealth for research into problems associated with sheep pastures, including the survey and establishment of pastures and the control of weeds and insect pests.

In 1951, the Commonwealth Scientific and Industrial Research Organization agreed to provide a very substantial proportion, over a period of ten years, of the costs of the establishment of a University Chair in Plant Genetics, to enable a strong post-graduate school in this subject to be developed at the Institute.

Under the original deed of gift it was provided that portion of the estate containing an area of 67 acres should be held in perpetuity as a public park. Effect has been given to this provision by the establishment of the Waite Arboretum, in which trees can be grown to demonstrate their value for shelter and ornament, and their adaptability to the local soil and climate. The Arboretum now has 1,090 trees belonging to 527 different species. The first plantings were made in 1928.

The library of the Waite Institute is designed to meet the needs of a research staff, and the policy is to make it as complete a reference library as possible on matters relating to agricultural science and its related scientific disciplines. The present total of books is 3,000, and of bound periodicals 4,800, with an additional 41,800 serials and pamphlets.

From the beginning of 1925 until early in 1938 the Waite Institute was under the direction of the late Dr. A. E. V. Richardson, which owes much to his organizing ability in its formative years.

Mr. D. B. Adam, whose death in February, 1951, is recorded with deep regret, had been Head of the Department of Plant Pathology since 1934. He had ideal qualities for the combination of academic and advisory work for which his department has been responsible. Dr. C. G. Hansford has been appointed to succeed him as Head of the Department and Reader in Plant Pathology in the University.

Professor J. A. Prescott, with the consent of the Council of the University, accepted an invitation from the Minister for External Affairs to be leader of a group of Australians sent by the Australian Government in March and April, 1951, to advise on the nature of the help that could best be given under the Commonwealth Technical Co-operation Scheme to the Government of Pakistan in the development of farming, especially by means of irrigation in the Thal region of the Punjab.

Dr. H. G. Andrewartha was appointed by the Commonwealth Government to be a member of the Sirex Wasp Committee.

During the two years under review, experimental work has been conducted at country centres with the goodwill and co-operation of a number of individuals and organizations. It is a pleasure to record such assistance from the following: Messrs. F. Coleman & Sons, Saddleworth; The Yudnapinna Pastoral Company; Mr. Peter Nicholls, Avon; Woods and Forests Department, Mount Burr; Mrs. A. B. Kidman, Naracoorte; Mr. T. R. Paltridge, Lucindale; Mr. T. N. Bell, Millicent; Mr. R. Pahl, Penola; Mr. R. Somerville, Penola; Mr. R. James, Lucindale; Mr. K. Miller, Springton; Messrs. James Bros., Meningie; Mr. A. H. Shearer, Waitpinga; Mr. G. T. Pitt, Wrattonbullie; Mr. D. W. Walker, Kalangadoo; Mr. J. C. King, Mount Schank; Messrs. W. S. Kelly & Son, Tarlee.

2. Scientific Work of the Institute.

The scientific work of the Institute is centred round the study of the principles of crop and pasture husbandry and of the scientific disciplines which may be associated with this aspect of agriculture. Animal husbandry is not a feature of the activities of the Institute except in so far as it is necessary for the study of pastures. The main subjects of investigation may be included in the following groups:

Agronomy and Agrostology.

The investigation of the factors affecting the production of farm crops and the improvement, establishment and management of pastures under the wide range of rainfall conditions prevailing in South Australia, the identification and control of weeds.

Genetics and Plant Breeding.

The investigation of the principles of inheritance in plants and their application in the improvement of agricultural and horticultural crops.

Plant Physiology.

The investigation of factors concerned in the growth reactions of crop plants, with particular emphasis on their water relations, and on the mechanism of elongation.

Plant Pathology.

The investigation of the diseases of agricultural and horticultural crops and of forest trees.

Entomology.

The investigation of the insect pests of agricultural and horticultural crops, of stored products and of forest trees.

Agricultural Chemistry.

The classification of soils; the investigation of soil fertility problems; the chemical study of plant viruses; the chemical study of pastures.

The Waite Institute, in addition to its principal function of research, provides scientific advisory services in systematic botany, plant pathology and entomology to the Minister responsible for the Departments of Agriculture and of Woods and Forests. The University of Adelaide maintains a School of Agricultural Science and in conjunction with the Roseworthy Agricultural College provides courses of instruction leading to the degree of B.Ag.Sc. Of these courses, those in the second and third year in agriculture, genetics, agricultural chemistry, mycology, plant pathology and entomology are provided at the Waite Institute.

Increasing use is being made of the facilities provided in the several departments for post-graduate training leading to the higher degrees.

The Work of the Institute

Agronomy and Agrostology

The main objectives of the researches conducted since March, 1925, have concerned the maintenance and improvement of the fertility resources and productivity of South Australian soils. The field experiments on the red-brown loams of the Waite Institute have demonstrated that neither favourable structure nor sufficiency of available nitrogen can be maintained for long on these soils, under the narrow crop rotations formerly practised. Emphasis has been increasingly given to the rôle of short-term and long-term pastures in improving both soil nitrogen and structure, to field peas as a rapid means of enhancing the protein status of the available forage and soil nitrogen, to oats for grazing and to new field crops such as flax, linseed and safflower as alternatives to wheat.

The recognized function of pasture development in building the fertility of both naturally poor and depleted soils has justified a series of researches, at the Waite Institute and at numerous country centres, directed to herbage species and strain improvement, herbage plant nutrition, competition in pasture communities, pasture management, and the control of noxious weeds. Studies of plant nutrition and response to artificial fertilizers have been related principally to areas in which climatic resources have been most liberal and soil nutrient deficiencies greatest. In the field of weed ecology, investigations of Cape tulip *(Homeria collina* and *H. miniata)* and wild onion *(Asphodelus fistulosus)* have been located in the older pastoral and agricultural areas of moderate rainfall. Researches on the management and regeneration of shrub pastures have been maintained in the arid northern areas of South Australia.

1. Permanent Rotation Experiment.

The permanent rotation plots up to 1948 involved comparisons of eleven systems of crop rotation, the main features of which have been described in previous reports. The broadest of these rotations, which also has given the highest wheat yield, was the four-course rotation fallow-wheat-oats-pasture. The most significant effect of including pasture leys is the improvement in soil structure. The results from the new rotations, including leys of up to four years, have not as yet been recorded over a sufficiently long period to make valid comparisons with the original rotations; but in the long-term rotations, those including pasture are showing a progressively greater proportional margin in wheat yield over the no-pasture rotations. The results of the experiment to 1951 of the new and original rotations are given in Table 1.

2. Investigations on Forage Crops and Temporary Pasture in Four-Course Rotations with Wheat.

This experiment is designed to determine the value of different forage crops for maintaining soil fertility. The results of the first two full cycles of the original rotations have been reported previously. The present rotations are:

A	*B*	*C*	*D*	*E*
Fallow	Fallow	Fallow	Fallow	Fallow
Wheat	Wheat	Wheat	Wheat	Wheat
Peas	Peas	Oats*	Oats	Fallow
Pasture	Pasture	Pasture	Pasture	Wheat

* With sulphate of ammonia added.

Pastures in *A*, *C* and *D* are Wimmera rye-grass, and in *B*, grazing oats. Superphosphate was applied to all crops and to the pasture. Half of each plot sown to forage was harvested each year whilst the other half-plot was grazed. The pastures were grazed twice each season, yields being obtained by sample cuts prior to grazing.

The changes made in the experiment were: in *B*, substitution of the clover forage crop and rye-grass pasture by peas and grazing oats respectively, and in *C*, the substitution of barley by oats with 2 cwt. of sulphate of ammonia per acre. These changes have permitted comparison of rye-grass and grazing oats as one-year pastures and also the comparison of the effects of biologically fixed nitrogen and applied mineral nitrogen.

The changes have resulted in interruption of the continuity of results for the forage crop, and this is the principle variable in the experiment. Tables on page 37 give the annual yields for 1950-51, the comparable mean yields for *A*, *B*, *C*, *D* and *E* since the changes were made, and the over-all means in *A*, *D* and *E*, the uninterrupted rotations.

The effects of eel-worm infestation on the oats of rotation *D* are reflected in continued marked depression of yields. In rotation *C*, the addition of sulphate of ammonia has resulted in improved yields of oats, but the subsequent pasture yields are still low and do not compare favourably with the pasture after peas. The most noteworthy result in the new series is the superiority of grazing oats as a one-year pasture.

3. Influence of Pastures and Forage Crops on the Yield of Wheat Grown in Rotations of Varying Duration.

Field investigations at the Waite Institute have increasingly emphasized the significance of the crop rotational system in governing soil productivity. The effects over a few seasons can be gauged by current yields of wheat, but the changes in the soil characteristics involved only accrue as a result of practices which are required to operate over periods of time approaching or exceeding a decade. For this reason the planning and conduct of experiments designed to provide specific data are to some extent presumptive, and are long in yielding useful information.

Crop rotation experiments prior to 1947 stressed three factors of particular significance, namely, (1) the length of the rotation, (2) the inclusion of annual legumes, (3) the rôle of grass-legume pastures, as determined by the kind of pasture, its management, and the period occupied by the ley.

The most recent investigation of these factors was begun as a combined field crop-pasture rotational experiment in 1947. At the outset the treatments adopted were preparational; useful data has accrued since 1949. The experiment includes five rotations as follows:—

A. *Two-course rotations.*

1. Fallow, wheat.
2. Peas (grazed), wheat.

B. *Four-course rotations.*

1. Pasture for two years, fallow, wheat.
2. Pasture for three years, wheat.

C. *Eight-course rotations.*

1. Pasture for six years, wheat, wheat.

The rotations were arranged in three separate sets, one to commence in each of the three seasons 1946, 1947, 1948, in order to spread the initiation of each separate rotation over a range of seasons. The pasture in all cases was based on subterranean clover (Bacchus Marsh) and phalaris (Gb81), maintained for two, three and six seasons in accordance with the treatments shown above. The peas were grazed after the seed pods became formed but prior to the final ripening of the grain.

The plots commenced in 1946 were discontinued and treatments not recommenced upon them until 1949; the rotations began according to plan in 1947, 1948 and 1949. The plots originally begun in 1946 and recommenced in 1949 have thus had an advantage of three seasons' rest from cropping, and this is apparent in the yields from this set.

The results for the five-year period 1947-51 have yielded the following provisional information, which of course applies only to this initial phase of the experiment.

(a) A comparison of the two-course rotations shows that over the first five years of the experiment, wheat after peas grazed by sheep averaged the same yield per acre (24·55 bushels) as wheat after fallow; in addition to this, peas averaged 39·48 cwt. (2 tons) of oven-dry forage per acre. One acre, over the four-year period 1948-51, would have produced 49·10 bushels of wheat when alternated with fallow, and 49·10 bushels of wheat *plus* 78·96 cwt. (4 tons) of peas as forage when fallow was replaced by peas.

(b) The yield of wheat in the four-course rotation of pasture for two years, fallow, wheat, was raised to 35·37 bushels per acre; but as only one crop of wheat was grown in four years, wheat production per unit area was only 72 per cent. of that yielded by the two-course rotations. The mean yield of pasture per acre per annum was 45·93 cwt. ($2\frac{1}{3}$ tons) on an oven-dry basis, or 91·86 cwt. (4·6 tons) from two years of pasture within a rotational cycle of four years. The production *in toto* was approximately 15 cwt. per acre more in the four-course rotation, but it is questionable whether the heavier yield of pasture, which exceeded the yield of peas by 12·90 cwt., compensated in the short-term net economic sense for the decrease in wheat production of 13·73 bushels.

(c) The yield of wheat in the four-course rotation of pasture for three years, wheat, was reduced by 5·66 bushels to 29·71 bushels per acre through elimination of the fallow and its substitution by a third year of pasture; but the production of sown pasture over the full rotational cycle of four years was raised by 56·04 cwt. (2·8 tons) to 147·90 cwt. (7·4 tons), or $2\frac{1}{2}$ tons per acre per year of pasture. Provided too great an emphasis is not placed on an immediate need for high wheat returns, this rotation can be regarded as the

most productive of all four in the initial phase, under the conditions of the experiment. Compared with peas, wheat, it yielded 19·39 bushels less of grain, but 68·94 cwt. (3½ tons) more of dry forage per acre in the four-year period.

(d) The elimination of fallow, whether by peas in the two-course rotation, or by a third year of seeded perennial pasture in the four-course rotation, greatly increased production in each case.

(e) The experiment has not proceeded sufficiently to enable the eight-course rotation to be assessed even tentatively. Over the five year period 1947-51, phalaris, subterranean clover, rye-grass pasture sown in 1946 has ranged in the yield of oven-dry herbage per acre from 34·69 cwt. in 1947 to 112·40 cwt. in 1951, averaging 63·85 cwt. over five years. This is capable of supporting six large-framed wethers per acre and producing wool of the order of 70-90 lb. per acre per annum; it is in line with previous experience at the Waite Institute.

4. Soil-Water-Plant Relationships under Dry Land Farming.

In 1948 a comprehensive field experiment was laid down at the Waite Institute to evaluate the Bouyoucos Electrical Resistance method of measuring soil moisture *in situ* and to study the soil moisture·changes under a simple crop rotation.

This Gypsum Block technique was shown to provide a valuable means of measuring soil moisture changes without disturbing the profile. Laboratory calibrations carried out in association with the Soil Physics Section, C.S.I.R.O., showed that the relationship between the logarithm of the Gypsum Block resistance and moisture tension (pF) was such that the log. resistance could be used as a direct indication of the moisture tension. Thus the resistance patterns plotted are also moisture tension patterns, and the data can be presented in terms of the availability of soil moisture. Further calibration was carried out to determine the relationship between block resistance and moisture content. This was done by field sampling when all replicate blocks indicated uniform moisture tension at a particular soil depth. It was then possible to calculate the amount of water stored in the profile at any given time.

The rate of moisture loss through evaporation from bare soil was shown to be related to the moisture content of the surface layers, and there was significant moisture loss to a depth of about two feet after the period of dry summer drought. The moisture conserved in the profile beyond this depth may be important in seasons with unfavourable opening rains, as in 1949 when 4·5 inches of moisture were stored. When the season is normally favourable the advantage in soil moisture conditions which fallowed plots have over non-fallowed plots is rapidly lost. This occurred in 1950 and 1951.

Monthly moisture losses from the growing wheat crop were calculated from the precipitation and the change in the amount of moisture stored in the profile. This monthly "evapo-transpiration" (E_{tr}) was related to the evaporation from a free water surface (E_w) giving the relationship $E_{tr} = 1{\cdot}67 \times E_w^{0{\cdot}75}$.

This relationship is illustrated in Fig. 1.

Because precipitation did not balance "evapo-transpiration" losses, depletion in stored water occurred so that at harvest time little available moisture is left to a depth of 5 feet. Piche Evaporimeter data obtained suggests that the greater part of the water lost by a crop during active growth is lost by transpiration and very little loss occurs by evaporation of rainfall intercepted by the vegetative canopy or of water directly from the soil.

The ungrazed phalaris-subterranean clover pasture stand was not wetted to the same extent by opening rains as the wheat plots. This is probably due to the interception of rainfall by the vegetative canopy and the earlier growth response of the pasture not allowing the same amount of accumulation of opening rains as is possible at this time when wheat is sown.

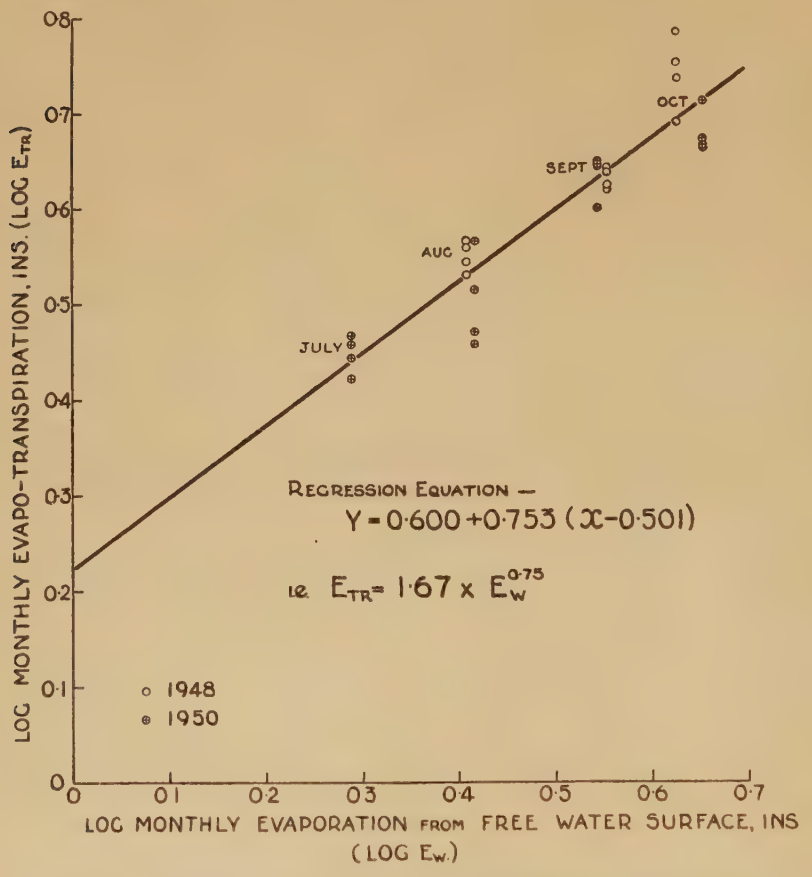

Fig. 1. Relationship between the measured evapo-transpiration from a growing crop and the evaporation from a free water surface.

5. Investigations of Improved Herbage Strains.

Medicago tribuloides (barrel medic).

A study on the autecology and ecotypic variability of *M. tribuloides* has been undertaken.

Thirteen collections from country centres were grown as spaced plants at the Institute. Observations and measurements on the numbers of days to flower, yield of leaf and stem, seed and burr weight and spininess, internode

length and number of stems were made. It was not possible to correlate variations in these with the environment of the origin of the collection. In a pot experiment, yield, leaf area and growth rates were measured.

The plant is largely restricted in its distribution to alkaline soils in the lower rainfall (12-20 inch) area.

The mean number of days to flower for the collections varied from 112 to 130, and the later-flowering types were actually later than Bacchus Marsh subterranean clover. Significant differences between collections were found for burr and seed weight and for other morphological characters.

The work reveals that there is much variability in these natural stands of barrel medic of which use could be made in any programme of improvement.

6. Taxonomic Investigations.

A preliminary taxonomic investigation was made on *Danthonia caespitosa* Gaudich, a species widely distributed in all temperate parts of Australia and important as a natural perennial grass in the pastoral areas. This species of Wallaby Grass has for many years been erroneously referred to as *D. semiannularis* (Labill.) R.Br. The name *D. semiannularis* should be applied solely to a distinct species restricted in distribution to Tasmania and the south coast of Victoria and south-east South Australia.

D. caespitosa shows a wide range of morphological variation and more than one form is frequently found associated in one locality. Considerable variation in gross characters, e.g. habit, foliage hairiness, panicle shape and anther colour, are found in addition to differences in the microscopic characters such as palea notching and hairiness of the lemma.

Numerous collections were made from various localities in South Australia and also some from Victoria, New South Wales and Western Australia. All these were grown under uniform field conditions. Fifteen readily distinguishable forms have been selected for further study.

7. Weeds Investigations.

(a) *Asphodelus fistulosus* (onion weed).

Field experiments to test the effectiveness of various pasture species as competitors of this extensively occurring weed, have indicated at the end of one year that several pasture species reduce considerably the population and size per plant of onion weed and in addition the quantity of seed it produces. Lucerne at 3 lb. per acre and a seeds mixture of perennial veldt grass 1 lb., barrel medic 2 lb., Wimmera rye-grass ½ lb., and lucerne 1 lb. per acre reduce the percentage cover most markedly.

Although it is too soon to assess the value of the sown species for permanent control, it seems likely that the use of improved pastures in association with cultivation, rotational farming and grazing management will provide an economic method of controlling onion weed under conditions of 12-16 inch annual rainfall. Such measures would be consistent with improvement of agricultural practices in the areas of low rainfall and light soils which characterise the bulk of the region affected by onion weed.

Pot culture experiments designed to support the field investigations have shown that onion weed grown in soil taken from infested areas at Avon is significantly depressed by dressings of nitrogen to the extent of 30 lb. nitrogen per acre, which on the other hand increased the growth of Wimmera rye-grass.

It has been observed that dense infestations usually occur on areas of low soil fertility due to natural causes or "cropping out." The investigations to date suggest that improvement will depend in part at least on legumes grown in long-term rotations in addition to inclusion of sown pastures in the rotations.

(b) *Homeria collina* and *H. miniata* (Cape tulip).

Investigations of Cape tulip *(Homeria collina* and *H. miniata)* and associated problems of grassland improvement in the regions of their occurrence were commenced in 1947. The work was carried out for a period of four years with financial assistance from the Australian Wool Research Trust Fund.

A field survey to determine the regional occurrence of the infestations was conducted in the four States, Western Australia, South Australia, Victoria and New South Wales, in which the two species were known to occur. The conditions of climate, soil and management governing the incidence and spread of the two species have been defined; and it has been shown that an extensive area of high potential value for pasture improvement is liable to invasion.

Soil deficiency and poor management leading to over-grazing, poor soil structure, and high available moisture levels of the surface soil in the winter period, were shown to be associated with the domination of unimproved pastures by the weed.

Cultivation at an appropriate phase of the annual life cycle proved to be effective if competently carried out over three successive seasons. Such treatment could be associated with crop production between the cultural operations required. Provided the elimination of the weeds in this period is accompanied or followed by a programme of crop or pasture development, both weeds can be permanently excluded from pastoral lands with economic advantage.

Certain weedicides of the growth-regulating type proved effective in eliminating the weed from non-arable areas such as fence lines, rocky outcrops, timbered country and watercourses. Owing to dormancy of the corms, spraying is necessary over three to four seasons for complete eradication.

8. Competition in Pasture Communities.

Suppression of *Phalaris tuberosa* by Wimmera rye-grass in a first-year pasture is a common observation which led to a closer investigation of the factors concerned in the competition of these two species. Pot and field investigations were carried out in which the growth rates, moisture uptake and root development of the two species were compared.

The competitive efficiency of rye-grass over *Phalaris tuberosa* appears to be related to the more rapid development of rye-grass plants as a whole in the early stages. This rapid development occurred for all plant parts (roots, stems and leaves) and in addition, differences in the root habits of the two species observed could give added advantages to the rye-grass.

The development and habit of the root systems was reflected in the moisture removal under stands of the two species, and the evidence suggests that under field conditions competition for moisture may be an important factor.

The more rapid development of the top growth of rye-grass compared with phalaris undoubtedly results in considerable shading of phalaris plants when the two are grown in association, so that competition for light may also be of importance.

The characteristics of rye-grass which exerted a dominating influence in the competition with phalaris in the first year, however, were no longer greater advantages in the second year. Two important factors in the success of phalaris over the annual rye-grass in the second year were its perenniality allowing it to take full advantage of the first rains at the break of the season, and the greater susceptibility of the rye-grass to the lowered fertility conditions resulting from the growth of a pure grass sward. Phalaris made more rapid development in terms of top growth and utilized moisture supplies much more rapidly and to a greater extent than rye-grass.

Further studies have been carried out using subterranean clover as well as phalaris and rye-grass in which seedling establishment and survival at the end of the season were observed. The association of rye-grass or subterranean clover with phalaris at the rates normally used in pasture seed mixtures at the Waite Institute did not affect the number of phalaris seedlings which established or the number surviving at the end of the season to a great extent, although yield per plant was reduced. Subterranean clover at a much heavier rate, however, markedly influenced the number of phalaris plants surviving at the end of the season, and this effect varied with the environmental conditions at the time of sowing. The survival of phalaris plants appears to be related to the density of the subterranean clover developing in association, so that conditions favourable for the development of a dense stand of subterranean clover appear to be unfavourable for the survival of phalaris seedlings.

9. Top Dressing of Natural Pasture.

A permanent field experiment to determine the effects of equivalent dressings of phosphate (40 lb. P_2O_5 per acre) in the form of superphosphate, basic slag and rock phosphate, and the effect of nitrate of soda added to the basal dressing of superphosphate, on the botanical composition and yield of a natural pasture, has been maintained since 1925. The results in terms of yield and stock-carrying capacity over 27 years are summarized in Table 4 on page 40.

Previous reports have recorded the major changes in botanical composition over the period of observation—i.e., the disappearance of perennial *Danthonia* spp. and the ingress of annual clovers, grasses and weeds. The most noteworthy result in view of the current shortage of superphosphate is the maintained high yield of herbage and high carrying capacity of the plot receiving rock phosphate. After the first six to eight years the total yield has equalled and later surpassed the yield obtained from the superphosphate plot. The experiment is being continued to record seasonal fluctuations in herbage production providing data for future analysis.

10. Grassland Investigations, South-East.

Investigations in this area were continued on a limited scale. The data obtained from an ecological survey of the pastures in the area has been published. This has defined the main pasture types in terms of botanical composition and their relationship to soil, climatic and management factors.

A series of field experiments arising from the survey and designed to provide more detailed information on the fertilizer requirements of sown pasture species on the rendzina soils and their halomorphic associates commenced in 1949 were continued in 1950. The initial year's results indicate the value of heavy dressings

of superphosphate for strawberry clover, 3 cwt. per acre being much superior to 1 cwt. per acre. Responses to zinc were obtained at most centres and in several cases responses to manganese were recorded as well. Yields obtained at the end of 1950 showed the desirability of heavy dressings of superphosphate even more markedly than in the initial year, while responses to zinc were again apparent. The effect of manganese applied in the initial year, however, was not so marked in the second year.

11. Investigations of Shrub Pastures under Low Rainfall.

Field researches have been conducted since 1938 at Yudnapinna Station, approximately 250 miles north-west of Adelaide. This centre is within, and representative of, the extensive north-western pastoral district of South Australia. A fully equipped meterological station has been maintained, and several of the main ecological features characteristic of the environment studied. The annual rainfall has averaged 7·92 inches for the period 1885-1951, and 8·80 inches for the period 1939-1951. This has proved sporadic, but there is a tendency for favourable and unfavourable seasons to lump together, so that variable runs of relatively abundant or deficient seasons may occur.

There is evidence of some winter rainfall dominance, despite the northerly location of the centre. According to the particular month, rainfall is sufficient in winter (May-August) to maintain growth during May in 42 per cent. of years, June—58 per cent., July—52 per cent., and August—39 per cent. of all years. On the other hand, there is a probable incidence of only 10 per cent. to 20 per cent. of all years for the remaining months (September-April).

The low nitrogen status of the soil appears greatly to limit production, even after useful rains occur. Natural regeneration is extremely low as a consequence.

Investigations of controlled grazing on unit plots of 160 acres have been maintained continuously since 1941. These have shown that bluebush country may be substantially improved by the adoption of relatively high stocking rates during periods when growth is active.

Pruning of the older bushes and consequent reduction of the transpiring surfaces of ephemeral grass and bluebush leaves result in vigorous production of young branches and an expansion of regeneration provided seeds of the bushes are produced in sufficient quantity. The experiments so far indicate that deterioration has been accentuated by extremes of under-grazing and over-grazing which are inevitable under conditions of minimum grazing control, arising from too few watering points located at the corners only of extremely large paddocks. It appears that a greater level of productivity together with long-term improvement of the country could be anticipated from suitably regulated grazing practices, should it become possible to adopt these on a practicable and economic scale.

12. Botanical Service.

Routine work of the botanical section consists largely of determination of plant specimens and of the unravelling of taxonomic problems associated with them for various members of the staff.

An advisory service in systematic botany is also available to the general public and to the Departments of Agriculture and of Woods and Forests. A close

liaison is maintained between officers of these departments and the systematic botanist. During the period 1950-1951 about 850 plant species were determined and reported on in this connection. Yellow Burr Weed *(Amsinckia hispida),* proclaimed a noxious weed in November, 1950, was received prior to that date as a potentially troublesome weed from Reedy Creek in the South-East. Hoary Cress *(Cardiaria draba,* synonym *Lepidium draba)* and Nutgrass *(Cyperus rotundus)* are subjects of numerous enquiries and would appear to be the two weeds causing the most concern to suburban gardeners. Dittander *(Lepidium latifolium)* has somewhat the same pernicious habits as its close relative, Hoary Cress, and since its first introduction in 1949, has been reported from three additional suburban localities. However, as it can be successfully controlled with the hormone-type weedicides, this should not occasion alarm. Musk Bugle *(Ajuga iva),* a herb native to the Mediterranean region, has been found growing spontaneously on the roadside near Moonta. Previously this plant has been found only in an isolated patch near Roseworthy.

Sweet-scented garlic *(Nothoscordum fragrans)* has been reported from three suburban areas where it is considered as a very bad weed. In Victoria it was listed as a naturalized plant in 1918, but it has not been previously recorded from South Australia. Sweet-scented garlic has, no doubt, escaped from cultivation. It should be watched as a potentially troublesome weed.

Red-flowered lotus *(Lotus coccineus),* false caper *(Euphorbia terracina)* and the native spurge *(Euphorbia clutioides)* have been sent in as plants suspected of poisoning stock in the northern pastoral areas. The plant, known locally as New Zealand Moss, and much publicized during the past two seasons as a wonder lawn plant, has been identified as a form of Pearlwort *(Sagina procumbens).* Pearlwort occurs naturally in moist situations in some parts of this State, and also in other States of the Commonwealth, but this particular form is not indigenous here. Pearlwort has been recognized as a weed in grass lawns both in Australia and overseas for many years. Its spongy habit of growth and the slippery nature of its fleshy leaves make it particularly troublesome in bowling greens, where a fine lawn of uniform texture is required.

Three native plants have been recorded from new localities. An epacrid *(Acrotriche patula),* recognized as a coastal species, is growing extensively in the Wirrabara forest area 12-15 miles inland. *Comesperma volubile,* a twining undershrub of the mainland, is reported to be common on coastal calcareous sands around Nepean, Vivonne and Emu Bay on Kangaroo Island, and *Ziera veronica,* a dwarf undershrub, not known previously from that locality, has been found in the upper South-East near Keith.

Several collections of native plants have been identified. These included two collections made on the shores of Lake Eyre after the recent floodings. No new plants were found amongst these.

Numerous requests are received for advice on trees and shrubs suitable for planting as windbreaks, on farms, in seaside areas and in suburban gardens. Increasing interest is shown in the cultivation of Australian native plants. Many samples of seed from trees, particularly eucalypts, in the Waite Institute Arboretum have been supplied in this connection.

Genetics and Plant Breeding

1. Wheat.

Two new varieties—Panther and Dirk 51—were released for general cultivation. Panther, selected from the cross Nabawa × Riverina × Hope, is a late-maturing variety, of good baking quality and possessing resistance to the South Australian races of stem and leaf rusts and flag smut. A crop of this new variety, grown at Cummins, was awarded first place in the State wheat crop competition of 1950-51. Dirk 51, a back cross derivative of the Roseworthy College variety Dirk, possesses resistance to stem rust and to all the Australian races of bunt. The American variety Orfed was used as the donor parent for bunt resistance.

Yield trials were continued at the Waite Institute and at Saddleworth, the results of which are tabulated on pages 42 and 43.

A genetic analysis was made of the resistance of Oro and Orfed wheats to one race of *Tilletia caries* and three races of *T. foetida.* The isolation of a number of distinct phenotypes exhibiting marked differential reactions to the four races indicated that inheritance of resistance was dependent on a number of genes.

In breeding for resistance to leaf rust *(Puccinia triticina)* the back cross method was adopted, using Kenya C.6041 and Uruguay 1064 as the resistant donor parents. This programme is nearly completed for five varieties. Resistance to stem rust has been bred into Quadrat from Gabo.

Genetic studies on the resistance of wheat to powdery mildew *(Erysiphe graminis tritici)* have reached the stage where three genes have been identified. The "Thew" gene was detected in eight varieties, and the "Sonora" gene in three varieties. The third gene was detected in one variety—Ulka.

Preliminary studies indicate a simple mode of inheritance of resistance to *Ustilago tritici.*

2. Barley.

Back crossed strains of Prior and Research barley have been secured which are resistant to local races of mildew *(Erysiphe graminis tritici)* and covered smut *(Ustilago hordei).* Yield comparisons are being made with their respective prototypes.

3. Flax.

Comparisons between a rust-resistant derivative of Norfolk Earl and the standard Liral Crown varieties have indicated that the former is at least equal to Liral Crown in yield and fibre qualities. Acknowledgment is made of the assistance given by the C.S.I.R.O. Flax Research Laboratory in the testing of plot material.

The work of identifying genes for resistance to two Australian races of *Melampsora lini* has been continued.

Progress has been made towards discovering the relationships of the genes for resistance possessed by the varieties Ottawa 770 B, Newland, Bison, Punjab 5, 806/3, Wada and Liral Crown to those already described by Flor in the United States of America.

The establishment of facilities for the growing and testing of flax under controlled conditions of light and temperature is going forward. By the use of them, the gene in Liral Crown has been found to be sensitive to temperature conditions.

4. Oil Crops.

Linseed: Yield trials (pages 43 and 44) of some Indian and American varieties and new strains bred from Punjab × Walsh showed several superior to Walsh. Resistance to rust, to pasmo and to a new disease causing collapse at the base of the stem, has been tested. Crystal and Sheyenne, which are highly resistant to pasmo, have been used in crosses. The effect of harvest time on yield and seed quality have shown maximum yields, oil contents and iodine numbers four weeks after flowering. Delay results in loss without improved quality.

Safflower: Some Indian varieties require higher temperatures for germination than those from other sources. Some varieties show a prolonged rosette stage, others elongate early, this habit being controlled photoperiodically. Studies of the extensive variability have continued. The pollination mechanism and breeding system have been investigated; there is a good deal of natural out-crossing.

Yield trials are reported on page 45. Oil contents vary from 28 to 40 per cent. and it is reasonable to expect still higher values in selected stocks. Iodine numbers show little variation from the average of 147, except for one introduction with a value of 98, which puts its oil into a different class of industrial use. Early sowing increases yield.

Preliminary trials have been made of poppies and castor beans.

5. Pasture Plants.

Danthonia: Cytological studies are being made as a background to genetical and taxonomic work with the genus. Chromosome numbers have been determined in fifteen native species. They show polyploidy, somatic numbers being 24, 48 and 72 in different species. All three chromosome numbers occur in one "species."

Danthonia caespitosa: It is evidently an aggregate and is undergoing taxonomic revision. No Australian species, so far, has the numbers 36 or 42, which have been found in New Zealand species. Further collections have been made in New South Wales and Victoria, especially from the Alps, and will be studied shortly.

The photoperiodic responses of four species were examined during the winter of 1951. They remain vegetative if given only 10 or 12 hours light per day, but flowering and seed formation is induced by 15 hours light per day. All tested species are long-day plants, a property which may be correlated with their geographical distribution.

Phalaris: A collection of a number of species of this genus has been made. Selfing studies have shown evidence of self-incompatibility in the perennial species *P. tuberosa, P. aquatica,* and *P. truncata.* The annual species, *P. minor, P. canariensis, P. paradoxa, P. platensis, P. angusta* and *P. brachystachys,* were highly self-fertile. A moderate amount of seed setting followed selfing in certain strains of *P. tuberosa.*

Agricultural Chemistry

The activities of the Department have been largely directed to a study of some of the chemical factors bearing on soil fertility, particularly in relation to the soils of Kangaroo Island, and to the availability of soil phosphates in the red-brown earths. Attention has also been given to a study of the nitrogen cycle in these soils and an active interest maintained in developing and improving methods for the chemical analysis of soils.

1. Soil Investigations on Kangaroo Island.

Steady progress has been made in the examination of the *Seddon* series of soils of Kangaroo Island, and the fertility status of these soils is being investigated by laboratory studies and by pot and field experiments. In the pot experiments subterranean clover has been extensively used because of its importance in the pastures being established on the island. Oats has also been used, as a second test plant, so as to be indicative of the growth of cereals and grasses in this soil.

The *Seddon* series of soils is characteristic of a large area of the lateritic soils of Kangaroo Island, now being developed by the South Australian Land Development Executive. The soils are extremely deficient in phosphorus and nitrogen. Applications of copper are also necessary in pasture establishment. Besides studying various aspects of these nutrient elements, attention is being devoted to other micro-nutrients and to potassium.

Phosphorus: In its virgin state the *Seddon* soil is extremely low in total phosphorus and it also possesses a very high phosphate fixation capacity. Pot experiments have shown marked responses in the growth of subterranean clover to applications of superphosphate up to 6 cwt. per acre, the highest rate so far tested. One of the most important features of the experiments to date is the relatively low level of phosphorus in the crop. Increased applications of phosphatic fertilizers have led to increases in yield without significant increases in the proportion of phosphorus in the dry matter of the plant. The response to and uptake of phosphorus from much heavier applications is now being investigated.

In view of the prevailing shortage of superphosphate and in order to explore the possibility of greater availability of other forms of phosphate, several less soluble phosphatic fertilizers have been examined in pot trials. A low-alkali silico phosphate (one of the thermic phosphates produced in Britain during the war) has given very promising results, yields of subterranean clover being superior to those produced by equivalent amounts of superphosphate at all levels tested. Early growth was also stimulated. Basic slag, calcium metaphosphate and defluorinated phosphate were inferior to superphosphate in stimulating early growth, although under the pot conditions they produced final yields comparable to that of superphosphate. Fused tricalcicphosphate was markedly inferior as a source of available phosphorus.

Nitrogen: The virgin soil is also very deficient in nitrogen, and in pot experiments all crops other than legumes need to be supplied with relatively heavy applications of nitrogen before growth becomes normal and other mineral deficiencies can be detected.

Under clover pasture in the field there is a good accumulation of soil organic matter and nitrogen. An examination of the surface soil of the Experimental Block on Kangaroo Island showed that after 10-12 years in pasture, there had been a build-up of total nitrogen from an initial value of 0·05 per cent. to 0·15 per cent. at the present time. Nitrification studies on these soils are mentioned later.

Copper: Small applications of copper are essential for the successful growth of pasture, and in pot experiments it has been found that applications of 7 and 14 lb. of copper sulphate per acre led to marked increases in the yield and copper content of clover. With oats, similar applications also led to significant increases in yield, particularly that of grain, but the increase in the copper taken up by oats was relatively small compared with that taken up by clover. The response in grain production in oats persists up to applications of 1 cwt. of copper sulphate per acre, but even at this level the increase in the amount of copper in the dry matter of the plant is small. This aspect of low copper absorption by oats is receiving further study.

Molybdenum: The pot experiments have disclosed a significant response in the growth of clover to small applications of molybdenum when other nutrient deficiencies are satisfied. Chemical analysis of the crops has shown that this added molybdenum is readily taken up by the plant and that its molybdenum content is increased manyfold.

Other Micro-Elements: In a pot experiment in which the acidity of the soil was varied by the addition of regulated amounts of sulphur or lime to give a range from pH 4·8 to pH 7·2, there were indications of a marginal deficiency of manganese in oats growing in those pots in the neutral range. Growth of clover was very poor in the neutral to alkaline range, the plants being small and chlorotic. This condition is being further examined. The increase in the alkalinity of the soil increased the uptake of molybdenum by the plants, particularly in the presence of added molybdenum. There was little evidence of any marked change in the availability of copper at the different pH levels tested.

Officers of the soil chemistry section are also co-operating in extensive field experiments which have been laid down on Kangaroo Island by the State Department of Agriculture. The soils of the experimental area were sampled prior to the establishment of the plots to supply basic information on the soil in the virgin state. By periodical and systematic sampling, changes in the nutrient status of the soil, due to the different systems of manurial treatment or pasture management, will be followed as development proceeds. Such changes are relatively slow, and this investigation is necessarily long-range in type and will yield results only after several seasons.

2. Availability of Phosphorus in the Soil.

Besides the investigations on the availability of phosphorus in Kangaroo Island soil, the long-term field experiment at the Waite Institute, designed to measure the residual value of superphosphate applied with previous crops and to correlate the responses to superphosphate with the phosphate status of the soil, has been continued. This experiment was laid down on a site which had been selected because its phosphate status had been built up by the accumulated residues from superphosphate (24½ cwt. per acre) applied with previous crops and pasture during the preceding 20 years. In the virgin state this site gave a marked response to superphosphate. The experiment has now been in

progress for four years. The wheat and barley crops have been analysed each season and the amounts of phosphorus removed from each plot determined. Very heavy crops were obtained from all treatments in the first three seasons. Yields, particularly of barley, were much lighter in 1951. This was largely a reflection of the unfavourable season.

Differences in the phosphate reserves of the different plots are still small, but depletion by the next two or three crops should bring about significant changes. So far, the yields of wheat from the plots treated with superphosphate equivalent to 11 and 22 lb. P_2O_5 per acre have not been appreciably superior to those from the control plots receiving no fertilizer.

The amounts of nitrogen removed by the crops year by year are also being determined. Large amounts of nitrogen were removed in the initial crops, the site having been under pasture for several years previously. A decline in the amount of this readily available nitrogen is now becoming apparent.

3. Nitrification Studies.

Particular attention has been given to a study of the nitrogen cycle in the Kangaroo Island soils. Because of its very low nutrient status generally, the *Seddon* soil has presented a very interesting problem. In its virgin state it has a very low nitrifying power, and this applies to both organic nitrogen naturally present and to added nitrogenous compounds. As would be expected, the rate of nitrification can be improved considerably by the addition of lime, but as this has a distinctly depressing effect on the growth of pasture, this is not of practical importance. The effect of additions of soluble phosphates and different micro nutrients on the rate of nitrification is being examined. Soil samples taken from areas which have been under clover pastures for a number of years showed a remarkable build-up both in soil organic matter and in nitrifiable nitrogen. The rate of nitrification in such soils appears to be normal.

The generally accepted theories regarding nitrification postulate nitrite as an intermediate product. However, experiment has shown that when nitrite is added to *Seddon* soil it is quite rapidly lost instead of forming nitrate as expected. A similar loss has been observed in sandy soils from Keith (see p. 26). The nature and cause of this rapid removal of nitrite is being investigated.

In these nitrification studies it has been necessary to examine the methods available for the determination of nitrates, nitrites and ammonia in soils and determine the conditions under which precise results can be obtained. For the determination of nitrates a very satisfactory technique has been developed using 3,4, xylenol. Precautions are necessary to avoid losses in the determination by anaerobic microbiological activity and by reduction of nitrate by soil organic matter. For nitrites a colorimetric method using sulphanilamide and napthyl ethylene diamine has been shown to be rapid, sensitive and accurate, provided proper precautions are taken in making the aqueous extract of the soil. Proper conditions for the precise determination of ammonia by the Nessler method have also been determined.

4. Miscellaneous Soil Studies.

Under the Fulbright Foundation of the United States, experiments have been carried out at the Institute by a visiting soil scientist on the mineralogy of soils in relation to their ability to supply the major plant nutrients and the

so-called micro elements. The research was greatly facilitated by the helpful co-operation of the S.A. Department of Mines in providing facilities for the use of their modern X-ray diffraction equipment.

A post-graduate research project was completed on the behaviour under electrodialysis of soils characterized by different clay minerals and on the titration curves of the soils so derived. The chemical characterization of the major soil types of part of the Barossa Valley was also undertaken as such a project. A further project, being carried out by a research student, deals with the availability and fixation of phosphorus and copper in certain soil types.

5. The Chemistry of Plant Viruses.

(a) *Strains of Tomato Spotted Wilt.*

Further experience has made it possible to extend the number of strains of the virus of Tomato Spotted Wilt (T.S.W.) to be recognized in our current material. The reaction of these strains to chemicals and to heat has been tested, but so far no significant differences have been found in the behaviour of the different strains to these agencies, and their differentiation is consequently still based on differences in the character of the interaction between the virus and its host plant, namely, the nature of the symptoms on a selected range of host plants (this seems to be related to the biochemical reactions induced by the virus in the plant) and also by the length of the incubation period and other similar factors.

In order to systematize nomenclature, the strains have been designated by letters of the alphabet. The strains previously reported as R and Etch have been renamed B and C respectively. The strains are named A, B, C_1, C_2, D and E. The order is roughly the chronological order of their discovery and happens also to be the order of the severity of symptoms on tomato plants, the severity decreasing from A to E.

All six strains have a thermal inactivation temperature within one degree of 46° C., all have a short life *in vitro* (less than 24 hours at 20°C.), and all are rapidly inactivated by the oxidants lethal to the original strains A and B.

During a term of study leave, opportunity was taken to survey in a broad way the occurrence of some of these strains of T.S.W. in other countries, based on inoculation tests carried out on the spot, on observed symptoms in the field and on an examination of local records. In the countries named the strains considered probably to be present are:

New Zealand (Auckland) -	A, B, C, D.
Hawaii (Honolulu) - -	C, probably A.
California and Oregon - -	A, B, C.
Wisconsin (Madison) - -	C.
New York (Ithaca) - -	A, C.
New Jersey - - - -	A, C.
England (Cambridge) - -	A, B, C.

In a previous report (1943-47) a new virus was reported associated with T.S.W. to which the name White Ring Spot (W.R.S.) was given. The symptoms invoked on plants, the resistance to heat and serological tests indicate this virus to be a new strain of Potato X.

The behaviour of these various strains suggest that it is doubtful whether such a thing as a "pure" strain exists in any plant. It seems more likely that many strains exist and that, for example, each of the six strains of T.S.W. recognized in our material consists of a number of related strains which could be separated by further work with selective hosts. Separation of such strains by physical or chemical methods is not yet possible but is a goal to be aimed at and is only likely to be attained when more is known concerning the chemical differences which are presumably the basis of strain variation.

(b) *Comparison of Metabolism of Healthy and Virus-infected Plants.*

Work on the fluorescent benzopyrone (scopoletin) reported on previously was continued. The techniques of electrophoresis on filter paper and of paper chromatography are being developed in a new approach to the question of the part played by scopoletin and other substances in the metabolism of normal and virus-infected plants.

Plant Physiology

A series of investigations has been initiated to evaluate the relative magnitudes of the resistances interposed in the vapour phase of the transpiration stream. A considerable amount of data has been collected relating transpiration rate to vapour pressure differences between leaf and ambient air, rate of air movement and stomatal movement. The latter has been measured by means of the resistance porometer, i.e., as the resistance of the stomata to viscous flow of air. For a complete analysis, however, the conductance of the stomata for diffusive flow is required. An attempt has been made to determine the relation between viscous and diffusive flow through the stomata, but technical difficulties have so far prevented a satisfactory solution. This is being further investigated; the relation is necessary before a full and satisfactory analysis of the data can be completed.

Although it is clear that the stomata provide the only effective mechanism at the plant's disposal for controlling water loss, evidence obtained elsewhere has suggested the presence of another factor which comes into operation during wilting and can reduce the transpiration rate after recovery. This factor appears to be associated with an increase in resistance of the cell wall to vapour movement, and is being investigated in a leaf chamber designed to measure transpiration under still air conditions. In this chamber, water lost from the leaf is absorbed by silica gel which is weighed *in situ*. Changes in water uptake, leaf water content, stomatal movement, and vapour pressure differences between leaf and desiccant are followed concurrently.

The absorption of 2,4:dichlorophenoxyacetic acid (2,4:D) by plants was studied. An assay method utilizing the inhibition of growth in length of cucumber roots was devised which was sensitive to 0·02 p.p.m. over the range 0-0·20 p.p.m. This assay was not sensitive enough to detect toxic amounts of 2,4:D absorbed by leaves of cape tulip *(Homeria collina)*; it would appear that less than 60 μgm. is sufficient to kill a cape tulip plant. Experiments with cucumber seedlings showed that inhibition of growth by 2,4:D is due to the undissociated molecules; evidence suggests that the increased effectiveness following the addition of ammonium sulphate or weak acids to sprays (Waite Report,

1948-49) results from the decrease in dissociation accompanying the increased acidity of the solution.

Morphological examination of 2,4:D-treated plants showed that this substance stimulates cell division and retards cell elongation. The increase in diameter of treated compared with untreated roots arises mainly from increased cell division. However, preliminary examinations suggest that although expansion of cells in all planes is retarded by 2,4:D, it is not completely inhibited, and any one cell continues growing for a much longer time than does an untreated cell. This and other evidence suggests that secondary deposition of cellulose may be checked, at least partially, by 2,4:D.

Entomology

During the two years under review the work of the department has been directed principally to the study of insect pests of pastures. The State Advisory Service in entomology has been maintained; teaching courses in entomology were supplied to students of agriculture and zoology.

Considerable progress has been made in the preparation of a textbook in insect ecology, in collaboration with a joint author from the University of Sydney.

1. Insect Pests of Permanent Pastures.

A grant from the Wool Research Trust Fund enabled the appointment of a full-time investigator to study the complex of pasture-damaging insects that comes under notice in the South-East. The nature of the entomological problems of this region were discussed at some length in the previous report in this series, to which those interested are referred.

During 1950-51, unfavourable weather conditions and other factors led to a dramatic reduction in the numbers of the underground grass grub *(Oncopera fasciculata* Walk.). As a result it caused negligible damage; it does, however, survive in locally favourable situations, and its relatively high reproductive capacity enables a rapid return to numbers that could produce widespread pasture damage when the appropriate weather pattern prevails. Insect natural enemies appear to play an extremely small part in limiting the numbers of this insect; although there is some evidence that diseases caused by micro-organisms may in certain circumstances be of importance, evidence has been accumulating which shows that the impact of wet or dry conditions is all-important in determining the mortality rate of grass-grub populations in their burrows in the soil. Abnormally dry conditions in October-November may cause heavy mortality among the newly-hatched caterpillars before they become established in the soil; conversely, abnormally heavy winter rains waterlog all but the best-drained soils (volcanic and terra rossa types), which results in a high death-rate from drowning. Both these factors were observed to operate during the period under review.

It is of interest that a second species of *Oncopera (O. intricoides* Tindale) was found in limited areas on black soil flats near Millicent. This species had previously been known only from the Melbourne district of Victoria.

The pasture cockchafer, *Aphodius howitti* Hope, was also further studied. It is much more widely distributed in South Australia than are the *Oncopera* species, and its range has now been shown to extend to Eyre and Yorke Peninsulas, Kangaroo Island, and the Mount Compass-Myponga area south of Adelaide. As more land within this zone is converted to sheep grazing, the importance of this insect may be expected to increase. Infestations in pastures tend to show up a number of years after grazing commences; the beetles thrive after the dung level of the pasture gets sufficiently high, and when a favourable combination of annual pasture elements and weeds is established.

Work on the black field cricket (*Gryllulus commodus* Walker) was continued and extended during 1950 and 1951. Particular attention was paid to the physiology of development of the eggs. Many eggs were found to enter diapause soon after being laid. Diapause development was most rapidly completed if the eggs were subjected to relatively low temperatures soon after laying. The duration of exposure to low temperature necessary for the completion of diapause development was shown to be shortest between 13° C. and 16° C., and to increase as the temperature departed from these limits. At the same time the proportion of eggs which successfully completed diapause fell as temperatures departed from the same limits. Eggs were found to vary greatly in the intensity of their diapause; some develop with no appreciable delay due to diapause. Among the eggs manifesting diapause, the duration of exposure to favourable low temperature necessary to promote competence to continue development at higher temperatures was much shorter in some than in others. Finally, the proportion of eggs showing no propensity for diapause varied greatly from year to year among crickets caught in the field in the same area.

The field work consisted in a continuation of the survey of cricket numbers and distribution that had been commenced in 1949. In that year the numbers of crickets taken over the South-East was, in general, fairly high. In 1950 the numbers fell to a low level, and in 1951, although the survey was not completed due to bad weather, the numbers rose again. The fall in numbers between the autumn of 1949 and 1950 was attributable to a very dry period which commenced in August and November, 1949, and was responsible for the death of a high proportion of the eggs by desiccation. The distribution of crickets was mapped each year, and it has been found that they are present only on black clay soils, or in areas where the soil is for some reason kept damp during the winter and spring. In 1950, when cricket numbers were in general low, it was found that they were also virtually absent from some areas where they had occurred in small numbers in the previous year. The soils of these areas were found to be of a more sandy nature and of lighter texture than the soils on which crickets persisted. In a few areas where the contents of clay and organic material were higher than in the surrounding country, no appreciable fall in numbers of crickets was observed.

The lucerne flea, *Smynthurus viridis* L., is a widespread pest of pastures, attacking clovers and other broad-leaved pasture elements. The possibility that it could be controlled on a field scale by means of the newer organic insecticides was investigated. Of those examined, gamma benzene hexachloride proved to be effective; D.D.T. has little effect. The cost per acre of any insecticidal treatment makes their use impracticable except on high-grade pastures; the problem of protection of unimproved pasture still remains to be solved.

Outbreaks of "cutworms" (caterpillars of various species of the family *Noctuidae)* are reported each year from both the pastoral and cereal belts; the intensity of infestation and the local areas concerned vary from year to year. Little is known about the species concerned, and about the factors that favour or limit outbreaks in South Australia. A survey was therefore begun to secure information concerning the seasonal incidence, distribution and food preferences of cutworms; it is proposed to study the principal species in greater detail in future years.

2. Other Investigations.

Attacks on a variety of crops by sap-sucking "leaf-hoppers" have been reported from time to time. These insects may reach enormous numbers in crops; as well as causing direct damage, a number of plant virus diseases are known to be transmitted by them in various parts of the world. In South Australia potato crops are subject to periodic heavy attacks by a leaf-hopper of this kind; in order to clarify the identification of the Australian members of the group, a taxonomic revision was undertaken, in which all available material was examined. For the Australian species previously included in the world-wide genus *Empoasca*, a new genus *(Austroasca)* was established; several new species were recognized, and it was shown that the common local species was *A. viridigrisea* Paoli. The study enabled some anomalies in the reported occurrence of exotic species of *Empoasca* in Australia to be clarified; it was shown that such species were in fact native species closely resembling the exotic forms. A survey is being made of the mites associated with fruit trees in the State, and of the scale insects. Observations have been continued upon the progress of the beetles *Chrysomela* spp. in controlling the weed *Hypericum perforatum* (St. John's Wort) in South Australia. Investigations are in progress that are aimed at evaluating the effectiveness or otherwise of parasites already liberated to control the cabbage butterfly *(Pieris rapae),* the cabbage moth *(Plutella maculipennis)* and the black scale *(Saissetia oleae).*

A detailed review of the phenomenon of diapause in relation to insect ecology was prepared; a study of the wings of *Diptera* was published, which included a new interpretation of wing venation within the order and proposed certain improvements in the classification of the veins.

3. Miscellaneous.

During 1951 no trace of either the Mediterranean fruit-fly *(Ceratitis capitata)* nor the Queensland species *(Strumeta tryoni)* was found. This was the fifth year of the eradication campaign undertaken by the State, and the first in which *Ceratitis* was not encountered.

Wood wasps of the genus *Sirex* continued to be intercepted by quarantine inspection, or to emerge from softwoods imported from European countries.

Advice was supplied to quarantine authorities concerning various aspects of the problem, including measures that might be taken at ports of entry to deal with infested timber.

Plant Pathology

The department has continued its activities along the three main lines of teaching, providing an advisory service in pathology to the Department of Agriculture and the Woods and Forests Department, and conducting research into specialized aspects of plant pathology. Shortage of staff and the untimely death early in 1951 of Mr. D. B. Adam, the Head of the Department, have seriously handicapped the work.

As part of the advisory service, and complementing the usual identification of diseases common to South Australia and modification of existing control measures to fit particular conditions, several problems of increasing importance were surveyed in more detail. It was possible to define two of these problems sufficiently to initiate research into them. They are as follows: the disease known as "bare patches" or "no growth patches" in pasture and cereal crops in the Keith area of the South-East, and around Smoky Bay on the West Coast; and a "decline" in certain local cherry varieties, particularly Williams Favourite, which has been observed in the Adelaide Hills over a number of years, and which has become more obvious in the last two or three years, involving some standard varieties in addition to the local ones. Other problems surveyed in less detail were: the disease known as "dying vines" in both the irrigated and non-irrigated areas, where vines of almost any age die out irregularly in a block; the general problem known as "damping off" in seedlings, with specific interest in its occurrence during the summer, when the fungus *Corticium praticola* has been demonstrated as an important pathogen; problems of potato growing in the Adelaide Hills, particularly the possible occurrence of "purple top wilt" and its relation to the virus disease of tomatoes known as "big bud."

Two new diseases, not previously recorded in South Australia, came to notice in the period under review. The first of these was the "damping off" in seedlings, particularly tomato, in the summer of 1950-51, caused by the fungus *Corticium praticola*. This fungus was described first in America in 1929, and was not recorded again until 1949, when it was found associated with a variety of plants in England by one of the departmental staff on leave in England. It is very similar to a better-known organism, *Corticium solani*, and has probably been isolated by other workers who have confused it with *C. solani*. The second was "Onion Smut," which is common in some other parts of the world and was recorded in two seedling nurseries near Adelaide in 1950. It appears likely that it will not become serious here because of the climatic conditions, but the Department of Agriculture took charge of the situation from the point of view of quarantine.

The following research projects were carried forward:

(1) "Take all" disease of wheat. The work on this problem was continued with field experiments and pot culture in the glass-house until the death of Mr. Adam in February of 1951. Preparations were made for a further study in the field of the carry-over of the disease in the roots of infected grasses, particularly barley grass. The fungus *Ophiobolus graminis* apparently does not survive as a free-living saprophyte in the soil, but infected grass roots

from the previous year serve as infection *loci* the ensuing year. Following the success of longer fallowing, referred to in a previous report, for effectively reducing the disease, the spread of the fungus from these infection *loci* was studied. In addition, using techniques partly developed by other workers for population studies in cereals, the effect of *Ophiobolus* infection on tillering, production of heads, numbers of grain per head, weight of grain, and total plant survival, was investigated.

In the green-house the study of the differential influence of factors such as soil moisture status, soil temperature, fertilizers on the pathogen, the host plant, and on the interaction, was continued to assist in the interpretation of the extensive pot culture work previously carried out both in this department and by workers in other institutes.

(2) Variation and specialization in *Rhizoctonia solani.* This fungus attacks a wide range of host plants including cereals, pasture grasses and legumes, and a variety of vegetables. Pathogenic strains or races have been shown to occur, with some strains being pathogenic to only one host family while others are pathogenic to two or more host families. A study of this pathogenic specialization has been made to determine at what stage of infection of the various host plants this specialization occurs.

Two stages of specialization have so far been demonstrated: (a) Immediate pre-penetration stage. There is evidence that a chemical stimulation of hyphae occurs on the external surface of the host, causing the hyphae to form definite structures called infection "cushions" or plates. Such hyphal organization does not occur under any other conditions of growth. The suggestion of the chemical stimulus extends the hypothesis of Brown that infection results only from a contact stimulus. (b) Post-penetration stage. Both pathogenic and non-pathogenic strains may penetrate a host, but whereas the pathogenic strain rapidly spreads through the tissue, an immediate hypersensitive reaction occurs with the non-pathogenic strain and the penetrating hyphae are killed.

In the field, various soils in which *Rhizoctonia* has been found occurring naturally, e.g., the "no growth" problem in cereals and pasture, have been investigated to determine what strains of the fungus are occurring there. Attention is also being given to the means of survival of the fungus during the summer, and the appearance of the disease the following autumn in roughly circular patches throughout the crop or pasture in affected paddocks.

(3) Survival of *Pythium* in the soil. Following earlier studies on pre-emergence rotting of peas due to attack by the soil-borne fungus *Pythium,* the influence of soil moisture and soil temperature on the survival of this organism in the soil was studied. The organism is able to survive at least two years in soil at 1·5 per cent. moisture kept at 25° C. If the temperature is raised to 40° C., the population is rapidly reduced. Correlating this laboratory work with summer field conditions, however, it was shown that the *Pythium* population would be reduced, the actual reduction depending on the particular summer weather, but it built up again so rapidly in the autumn that it did not give any appreciable control of diseases caused by *Pythium.*

(4) Black Spot *(Venturia inaequalis)* of apple. The carry-over of this fungus through the winter as superficial conidia on twigs, twig lesions, bud scale infections, and perithecia in fallen leaves, was studied. Spring infections on the developing foliage and fruit were found to be due to either bud scale

infections or from ascospores discharged from fallen leaves. Ascospore discharge continued much later than October as originally supposed, and extended at least into December.

(5) "Gummosis" of apricots. The work was severely handicapped by the lack of a full-time research officer. Searches to find the perfect stage of the *Cytosporina* were continued, and further studies were carried out on the associated *Cryptovalsa*, but without gaining any new information on the mode of spread of the disease. In the field, apricot orchards containing trees similar in variety, age, management, etc., but varying markedly in the severity of "Gummosis," were selected for closer survey work in an attempt to determine what field conditions, if any, influenced the spread and severity of "Gummosis."

(6) Microbiology of Keith soil. In conjunction with a project of the University Department of Botany, an investigation was commenced to study the microflora of the deep sands near Keith, and to study some aspects of the nitrogen metabolism of these soils with particular reference to nitrification, since the nitrogen status is extremely low. The microflora was found to be predominantly fungal, and the rate of nitrification was low. Addition of copper and zinc did not affect nitrification. As in the case of the *Seddon* soil mentioned previously, on addition of nitrite to the soil it disappeared rapidly without any reflection in the level of nitrate. Investigation showed this disappearance was independent of the microflora and suggested a chemical removal.

(7) Virus investigations. An investigation was begun into the decline in cherries in the Adelaide Hills. Grafts of standard varieties put into local varieties such as Williams Favourite for pollination purposes frequently resulted in the death of the local variety within 4-5 years, but the grafts remained healthy until the whole tree collapsed. Together with other field evidence, this suggested the problem was in fact a virus disease. Controlled grafting was carried out during 1951 to examine the effects in more detail, and seeds of various stone fruits were collected and germinated to establish a stock nursery for further testing of the virus hypothesis.

Investigations on the transmission of viruses by seed were begun. Various hypotheses have been advanced by different workers to account for the small number of virus diseases transmitted by seed. These hypotheses are to be tested, but in the period under review the main task has been to develop suitable techniques for testing the presence of the virus in the various parts of the host plant, and in selecting virus diseases most suitable for the studies.

(8) Legume seed inoculation. The demand by farmers for cultures of *Rhizobium* for legume seed inoculation has increased so greatly that in the period under review this department took over the responsibility for preparation and distribution of the cultures from the C.S.I.R.O. Division of Soils, and in 1950 approximately 3,300 cultures were distributed. In addition to this service, strains from different sources were tested to obtain those most efficient for the particular legume crop being grown. Cultures for all leguminous crops were certified and were available for distribution.

Climatology

The interest in climatology, which has been a characteristic feature of the work of the Waite Institute since its foundation, has been maintained.

Work on the comparative climatology of Australia and Argentina was completed to a stage suitable for publication. These comparisons have been based on the parallelism between temperature regimes and moisture regimes. Temperature regimes were defined in terms of the wave form characteristics of mean, amplitude and phase, while moisture regimes were defined in relation to rainfall as modified by evaporation, using saturation deficit as an index of this latter. Actual evapo-transpiration from crops and vegetation was estimated to be a function of s.d.$^{\cdot 75}$. For drought-resistant crops at low moisture requirement, the evapo-transpiration is assumed to 8 s.d.$^{\cdot 75}$, and for average conditions with soil moisture maintained at an adequate level, 12 s.d.$^{\cdot 75}$.

To assist other workers engaged in similar calculations, tables of numbers to the power of 0·75 have been prepared and published.

The lag of temperature behind solar radiation is the most useful way of expressing phase. World maps have been published showing the extent of this lag expressed in days, in the case of air and sea-surface temperatures.

A detailed comparison of the temperature regimes of California with those of Australia is in progress.

Increasing attention has been given to the estimation of evaporation from a free water surface, which is the ultimate surface of reference in climatological work. In particular, the behaviour of the Piche evaporimeter has been studied, and the relationship of the observed evaporation to wind velocity and "wet-bulb" saturation deficit established.

It should be possible to estimate the evaporation from a standard water surface exposed to solar radiation from a knowledge of air temperature and humidity, wind and sunshine, and the necessary basal calculations have been undertaken preparatory to the preparation of evaporation maps.

Meteorological Records

Meteorological observations in connection with the work of the Waite Institute are being made at two centres, at the Waite Institute itself and at Yudnapinna (north-west of Port Augusta). Observations made since 1938 at Pallamana in the Murray Mallee (north-west of Murray Bridge), apart from rainfall measurements, have been discontinued. The records for 1950 and 1951 are given in the following tables.

Monthly rainfall and evaporation in inches for 1950 and 1951, Waite Institute.

	Rainfall		Evaporation	
Month	1950	1951	1950	1951
January	0·09	0·80	7·94	10·86
February	0·87	0·58	6·24	7·94
March	0·26	0·06	6·03	6·86
April	0·46	2·98	4·24	3·29
May	5·35	4·76	2·78	2·18
June	3·26	4·01	1·74	1·56
July	2·34	7·21	1·95	1·30
August	2·38	3·53	2·61	1·73
September	2·20	0·35	3·52	3·02
October	3·04	3·56	4·54	4·59
November	1·17	0·62	6·30	6·36
December	0·62	2·84	9·21	7·98
Total	22·04	31·30	57·10	57·67

Mean monthly air temperatures for 1950 and 1951, Waite Institute.

	Maximum		Minimum		Mean	
	1950	1951	1950	1951	1950	1951
Month	°F.	°F.	°F.	°F.	°F.	°F.
January	79·6	88·5	58·9	68·3	69·3	78·4
February	78·9	83·9	60·7	63·0	69·8	73·5
March	76·3	80·8	57·7	61·0	67·0	70·9
April	73·1	65·6	56·8	53·9	65·0	59·8
May	66·7	62·6	53·0	51·0	59·9	56·8
June	58·9	59·9	46·5	48·3	52·7	54·1
July	58·7	56·7	46·4	45·1	52·6	50·9
August	60·0	56·4	46·2	44·7	53·1	50·6
September	65·5	64·7	50·2	49·4	57·9	57·1
October	67·9	68·7	52·0	51·2	60·0	60·0
November	75·7	71·2	55·2	53·7	65·5	62·5
December	85·2	80·1	62·8	59·8	74·0	70·0
Mean	70·5	69·9	53·9	54·1	62·2	62·1

Mean monthly soil temperatures at 1 inch, 6 inches, 12 inches and 24 inches for 27 years, 1925-1951, Waite Institute.

	At 1″		At 6″		At 12″*		At 24″*	
Month	Max. °F.	Min. °F.	Max. °F.	Min. °F.	Max. °F.	Min. °F.	Max. °F.	Min. °F.
January	109·5	64·0	85·6	71·4	78·3	73·0	73·7	71·5
February	106·3	63·7	84·3	71·0	77·9	72·8	74·2	72·1
March	100·2	61·3	80·0	68·2	75·0	70·2	72·4	70·3
April	82·2	54·9	69·1	60·5	66·7	63·4	66·8	64·8
May	69·7	50·0	60·9	54·5	60·2	57·7	61·5	59·6
June	62·7	46·4	55·2	50·1	54·9	52·8	56·1	54·9
July	60·9	45·4	53·5	48·6	53·1	50·9	53·9	52·7
August	64·5	46·4	55·9	50·0	54·3	52·2	54·4	53·0
September	73·2	49·5	62·0	53·9	58·8	55·5	57·5	55·8
October	83·1	53·8	69·0	58·5	64·2	60·2	61·8	59·9
November	94·7	58·8	77·0	64·2	70·2	65·6	66·7	64·6
December	104·5	62·5	82·9	69·1	75·4	70·3	71·2	68·9
Mean	84·3	54·7	69·6	60·0	65·8	62·1	64·2	62·3

* The records for 1949 at 12 inches and 24 inches are incomplete. The values for this year have been estimated by reference to the temperature of the air and at depths of one and six inches.

Wind velocity at 2 metres and 1·25 metres from the ground from cup anemometers for the years 1950 and 1951. Waite Institute. Miles per day.*

	2 Metres		1·25 Metres	
Month	1950	1951	1950	1951
January	96	117	90	100
February	96	98	89	85
March	90	94	81	81
April	79	97	71	83
May	85	91	75	80
June	70	62	61	55
July	83	94	77	84
August	84	87	75	77
September	99	80	85	71
October	91	106	75	93
November	107	102	91	88
December	107	109	90	94
Mean	91	95	80	83

* For the years 1938-1949, these measurements were made at 8 feet from the ground.

General Climatological Data.

The most important data on which are based studies of climatology as applied to agriculture and biology involve rainfall, evaporation, temperature and humidity.

Evaporation from a free water surface is dependent on temperature, humidity, sunshine and wind. Estimates of evaporation have usually been made in the work of the Waite Institute on the assumption that it is proportional to

saturation deficit when comparisons made for two or more localities relate to the same month. The ratios of precipitation (rain, hail, snow and dew) to evaporation or saturation deficit have been found of special value in agro-climatological studies. A ratio of more universal application has been found to be that of precipitation to the 0·75th power of evaporation or atmospheric saturation deficit, and this ratio is being increasingly applied and tested. It can be assumed that monthly values of $1{\cdot}2E^{\cdot75}$ or 12 s.d.$^{\cdot75}$ correspond closely to the evaporation from a vegetated land surface with adequate but not over-abundant soil moisture. For drought-resistant crops at the lowest level of production the value is closer to $0{\cdot}8E^{\cdot75}$.

Climatological data for the Waite Institute. Mean of 27 years, 1925-1951.

Month	Precipitation inches	Evaporation inches	Temperature Max. °F.	Temperature Min. °F.	Temperature Mean °F.	Relative Humidity per cent.	Bright Sunshine hours per day
January	0·95	8·62	81·6	60·4	71·0	48	8·8
February	1·20	6·99	80·8	60·6	70·7	52	8·5
March	0·86	6·41	78·3	59·4	68·8	52	7·6
April	2·01	3·95	70·2	54·3	62·2	62	5·6
May	3·06	2·69	64·2	50·7	57·4	68	4·1
June	2·89	1·74	58·8	46·5	52·6	75	3·2
July	3·22	1·74	57·3	45·3	51·3	76	3·2
August	3·07	2·30	59·2	45·9	52·5	71	4·5
September	2·47	3·24	63·9	48·2	56·0	64	5·7
October	2·24	4·60	68·2	50·7	59·5	60	6·6
November	1·47	6·12	74·0	54·7	64·3	54	7·7
December	1·18	7·83	79·0	58·1	68·5	50	8·3
Total	24·63	56·23	Mean 69·6	52·9	61·2	61	6·2

Calculated to a standard month of 30·4 days.

Month	Precipitation (P) inches	Evaporation (E) inches	Saturation deficit (s.d.) inches of mercury	Water need of vegetation low $0{\cdot}8E^{\cdot75}$ inches	Water need of vegetation moderate $1{\cdot}2E^{\cdot75}$ inches	Water need of vegetation high $1{\cdot}6E^{\cdot75}$ inches
January	0·93	8·46	0·398	3·97	5·95	7·94
February	1·29	7·52	0·363	3·63	5·45	7·27
March	0·85	6·29	0·341	3·18	4·77	6·36
April	2·04	4·01	0·214	2·27	3·40	4·53
May	3·00	2·64	0·152	1·66	2·49	3·31
June	2·93	1·76	0·100	1·22	1·83	2·44
July	3·16	1·71	0·091	1·20	1·80	2·39
August	3·01	2·26	0·115	1·48	2·21	2·95
September	2·51	3·28	0·163	1·95	2·92	3·90
October	2·20	4·51	0·205	2·48	3·71	4·95
November	1·49	6·20	0·279	3·14	4·71	6·29
December	1·16	7·68	0·351	3·69	5·54	7·38
Total	24·57	56·32	Mean 0·231	Total 29·87	44·78	59·71

RECORDS AT YUDNAPINNA

Monthly rainfall and evaporation in inches for the years 1950-1951.

Month	Rainfall		Evaporation	
	1950	1951	1950	1951
January	0·08	0·09	16·00	15·19
February	2·45	0·01	10·42	12·37
March	1·10	0·38	9·51	10·46
April	0·01	0·21	6·99	6·14
May	3·24	0·27	5·85	3·98
June	0·72	3·74	2·20	1·72
July	0·10	1·41	2·97	2·58
August	0·16	0·32	4·54	3·42
September	0·15	0·28	7·92	5·70
October	0·88	0·20	9·00	10·18
November	1·72	0·02	11·09	12·35
December	0·55	0·87	14·13	14·32
Total	11·16	7·80	100·62	98·41

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I. FIELD CROPS, PASTURES AND FORAGE PLANTS.

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II. AGRICULTURAL CHEMISTRY.

J. A. Prescott. "Scientific Research into Soil Fertility in South Australia." Comm. Bank of Aust., "Building Soil Fertility in S.A., 13-16. 1950. (Reprint 546.)

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Records of Field Experimental Work

1. PERMANENT ROTATION EXPERIMENT, 1926-1951.

Effect of different crop rotations on the yield of wheat.

A number of the original rotations in this experiment were discontinued as from 1947, and these have been replaced by modern rotations involving longer periods under sown pasture. The peas-wheat-barley rotation was, however, re-introduced and the first valid yields began again in 1951. It will be some years before the results of the new rotations become applicable, but the yields have been recorded to facilitate future tabulation of results. The original numbers of the unchanged rotations are given for reference purposes and the present numeration is given in the adjacent column.

Variety of crop and seed rate per acre: Sepoy wheat (1926-34), Seewari (1935-47), Seewari 48 (1948-51), 80-90 lb.; Early Burt oats, 60-70 lb.; Prior barley, 70-80 lb.; White Brunswick Peas, 120-150 lb.; Wimmera rye-grass, 10-15 lb. (1926-45), and Wimmera rye-grass, 3 lb. + Fulghum oats, 40 lb. (1946-51) on rotations 3 and 9; Wimmera rye-grass, 3 lb. + subterranean clover, 6 lb. on rotations 7 and 11; phalaris, 3 lb. + subterranean clover, 6 lb. + lucerne, 1 lb. + Wimmera rye-grass, ½ lb. on rotations 5 and 10.

Basal dressing of superphosphate, 187 lb. per acre (1929-42), 94 lb. per acre (1944-51).

Design: Unreplicated, but each course of all rotations is represented each year.

Area of each plot = $^1/_7$ acre (1926-37), $^1/_{7.619}$ acre (1938-51). Total yields in all cases are based on air-dry weights.

Prev. No.	New No.	Crop	Period	1948 Total cwt.	1948 Grain bush.	1949 Total cwt.	1949 Grain bush.	1950 Total cwt.	1950 Grain bush.	1951 Total cwt.	1951 Grain bush.	Mean to 1949 Total cwt.	Mean to 1949 Grain bush.	Mean to 1951 Total cwt.	Mean to 1951 Grain bush.	No. years record to 1951 incl.
1	1	Fallow	1926-51													
		Wheat		28·10	17·80	43·66	32·25	35·64	29·75	12·28	3·13	**49·08**	**33·61**	**47·15**	**32·29**	26
2	2	Peas	1926-51	9·72	7·84	34·08	not recorded	28·86	19·07	21·78	11·09	**29·33**	**19·82**	**29·02**	**19·44**	26
		Wheat		35·20	24·25	45·52	31·76	29·00	6·05	7·81	3·13	**38·20**	**26·45**	**36·67**	**24·77**	26
3	3	Fallow	1926-51													
		Wheat		43·65	35·33	65·68	53·07	58·72	49·89	14·12	9·90	**58·54**	**40·42**	**56·83**	**39·61**	26
		Pasture		39·27		36·29		30·37		24·70		**30·49**		**30·25**		25
4	4	Fallow	1926-51													
		Wheat		47·97	37·04	56·23	43·78	46·16	36·79	15·91	*	**56·41**	**36·11**	**54·46**	**34·75**	26
		Oats		26·09	18·05	32·85	33·87	11·23	8·61	36·27	*	**39·12**	**41·20**	**37·94**	**38·36**	26

1. PERMANENT ROTATION EXPERIMENT, 1926-1951 (continued).

Prev. No.	New No.	Crop	Period	1948 Total cwt.	1948 Grain bush.	1949 Total cwt.	1949 Grain bush.	1950 Total cwt.	1950 Grain bush.	1951 Total cwt.	1951 Grain bush.	Mean to 1949 Total cwt.	Mean to 1949 Grain bush.	Mean to 1951 Total cwt.	Mean to 1951 Grain bush.	No. years record to 1951 incl.
—	5	Pasture 1st year	1948-51	62·81		43·98		35·40		37·19		53·40		44·85		4
		Pasture 2nd year				40·46		67·32		103·35		40·46		70·38		3
		Pasture 3rd year						67·67		99·14				83·41		2
		Pasture 4th year								157·56				157·56		1
		Wheat 1st year														
		Wheat 2nd year														
7	6	Wheat	1926-51	24·53	14·98	25·43	9·04	30·00	*	28·81	*	25·40	14·13	25·71	13·04	26
—	7	Pasture 1st year	1951							24·30				24·30		1
		Pasture 2nd year								105·34				105·34		1
		Wheat														
9	8	Peas	1926-47													
			1951							23·40	17·05	38·32	29·94	37·67	29·37	23
		Wheat								28·64	25·08	49·86	34·17	48·94	33·78	23
		Barley								8·78	8·23	43·49	43·85	41·98	42·30	23
10	9	Fallow	1926-51													
		Wheat		57·14	43·62	81·43	66·09	62·11	51·84	16·12	11·56	68·18	45·72	65·95	44·64	26
		Oats		27·75	18·62	36·67	36·20	40·20	38·72	12·96	*	48·33	52·15	46·65	49·63	26
		Pasture		37·78		54·00		32·27		27·47		33·90		33·58		25
—	10	Perm. Pasture	1951							27·87				27·87		1
—	11	Fallow	1948-51													
		Wheat						54·49	43·24	30·68	24·19			42·59	33·72	2
		Pasture 1st year		53·13		74·17		49·20		10·54		63·65		46·76		4
		Pasture 2nd year				62·68		70·79		117·18		62·68		83·55		3
12	12	Fallow	1926-51													
		Wheat		38·34	27·27	53·13	38·42	44·01	34·92	13·71	5·86	54·82	37·34	52·82	36·03	26

* Crop heavily infested with weeds and cut for hay; grain yield negligible.

2. INFLUENCE OF GRAZED AND HARVESTED FORAGE CROPS ON THE YIELD OF TEMPORARY PASTURE AND WHEAT IN FOUR-COURSE ROTATIONS, 1937-1951.

Present rotations:

A	B	C	D	E
Fallow	Fallow	Fallow	Fallow	Fallow
Wheat	Wheat	Wheat	Wheat	Wheat
Peas	Peas	Oats*	Oats	Fallow
Pasture**	Grazing oats	Pasture**	Pasture**	Wheat

* With sulphate of ammonia added. ** Wimmera rye-grass.

Results of the first two cycles of original rotations are given in the 1943-47 report, but the means for the unaltered rotations to 1951 have been included as well as the means of these rotations (A, D and E) comparable with the means to 1951 of the new rotations B and C.

Variety of crop and seed rate per acre: Seewari 48 wheat, 80-90 lb.; Mulga oats, 60-70 lb.; White Brunswick peas, 120-150 lb.; Fulghum grazing oats, 60-70 lb. ; Wimmera rye-grass, 10 lb.

Fertilizer: Basal superphosphate applied at 1 cwt. per acre. Sulphate of ammonia at 2 cwt. per acre applied to oats on rotation C.

Forage crop treatment: G = grazed, H = harvested.

Design: 60 main plots in 4 groups of 15 plots, each group representing one course of the rotations. The groups of 15 plots are divided into 3 randomized blocks in which each rotation is represented by a plot. The plots are subdivided into halves; on one half the forage crop is grazed, and on the other it is harvested.

Area of main plots = $^{1}/_{6{\cdot}94}$ acre.

(a) Yields of forage crops (air-dry).

	A Peas			B Peas			C Oats*			D Oats		
	G	H		G	H		G	H		G	H	
Year	cwt.	cwt.	bush.	cwt.	cwt.	bush.	cwt.	cwt.	bush.	cwt.	cwt.	bush.
Mean 1937-49	48·55	36·97	29·66	—	—	—	—	—	—	17·25	16·99	18·73
Mean 1946-49	53·69	33·46	29·26	51·03	39·76	34·42	36·97	33·46	33·71	13·12	8·46	8·75
1950	54·51	29·84	25·36	53·26	39·75	35·56	40·14	43·29	48·25	9·34	7·46	10·59
1951	54·34	36·61	31·40	62·37	42·13	37·34	17·05	20·99	23·87	2·26	2·92	2·34
Mean 1946-51	53·94	33·38	28·96	53·29	40·15	35·08	34·18	33·02	34·49	10·68	7·37	8·27
Mean 1937-51	49·33	36·47	29·49	—	—	—	—	—	—	15·73	15·42	17·10

* With sulphate of ammonia added.

(b) Yields of temporary pasture (air-dry) in cwt. per acre.

	A Wimmera Rye Grass after Peas		B Oats after Peas		C Wimmera Rye Grass after Oats*		D Wimmera Rye Grass after Oats	
Year	G	H	G	H	G	H	G	H
Mean 1938-49	51·95	33·92	—	—	—	—	13·64	9·61
Mean 1947-49	45·39	28·82	57·25	41·51	18·46	7·49	11·55	5·96
1950	23·96	14·21	48·36	27·31	9·11	3·15	4·27	3·00
1951	35·81	26·20	55·82	47·78	17·16	8·91	12·54	9·80
Mean 1947-51	39·19	25·38	55·19	39·93	16·33	6·91	10·29	6·14
Mean 1938-51	48·80	31·96	—	—	—	—	12·89	9·15

(c) Yields of wheat in bushels per acre.

	A		B		C		D		E	
Year	G	H	G	H	G	H	G	H	G	H
Mean 1940-49	44·69	40·99	—	—	—	—	35·36	33·23	31·52	29·76
1950	51·73	44·71	50·20	46·98	40·31	33·76	34·17	30·86	29·42	28·13
1951	23·45	21·85	22·22	24·59	20·93	21·56	19·32	19·37	9·07	9·83
Mean 1949-51	44·18	38·74	43·25	40·91	35·03	31·32	30·79	28·90	26·99	25·42
Mean 1940-51	43·50	39·70	—	—	—	—	33·93	31·87	29·48	27·96

* With sulphate of ammonia added.

3. INFLUENCE OF PASTURES AND FORAGE CROPS ON THE YIELD OF WHEAT GROWN IN ROTATIONS OF VARYING DURATION.

Combined field crop—pasture rotational experiment begun in 1947 with the object of comparing two-course and four-course rotations and an eight-course rotation, based on (1) Fallow, wheat; (2) Peas (grazed), wheat; (3) Pasture for two years, fallow, wheat; (4) Pasture for three years, wheat; (5) Pasture for six years, wheat, wheat.

The field had previously been subjected to a long period of wheat, bare fallow; and the investigations provide scope for examining the effects of the rotations on the nitrogen status and physical properties of the soil, as well as on forage and crop production.

Variety of crop and seed rate per acre: Seewari 48 wheat, 80-90 lb.; White Brunswick peas, 120-150 lb. Pasture mixture of Bacchus Marsh subterranean clover, phalaris, Wimmera rye-grass, lucerne. Basal superphosphate 112 lb. per acre per annum with each season of crop and of pasture.

All five of the rotations were commenced three times in each of the three seasons 1947, 1948, 1949. Those begun in 1949 were originally established in 1946 but not proceeded with until 1949; they have thus had an advantage of three seasons' rest from cropping, and this is apparent in the yields from this set.

Total of 30 plots, each 2·00 × 0·40 chains ($^1/_{12·5}$ acre), made up of rotations (5) × seasons (3) × replications (2).

Yields of peas and pasture on oven-dry basis.

Rotation	*Fallow, wheat* (bush. per ac.)		*Peas (grazed), wheat* (Peas, cwt. dry per ac.; Wheat, bush. per ac.)		*Pasture, pasture, fallow, wheat* (Pasture, cwt. dry per ac.; Wheat, bush. per ac.)		*Pasture, pasture, pasture, wheat* (Pasture, cwt. dry per ac.; Wheat, bush. per ac.)	
	Commenced	Commenced	Commenced	Commenced	Commenced	Commenced	Commenced	Commenced
Year of harvest	1947	1948	1947	1948	1947	1948	1947	1948
1947	Fallow	—	Peas 77·15	—	Pasture 35·11	—	Pasture 33·26	—
1948	Wheat 25·03	Fallow	Wheat 30·53	Peas 50·60	Pasture 75·99	Pasture 29·67	Pasture 73·27	Pasture 38·49
1949	Fallow	Wheat 37·00	Peas 18·45	Wheat 37·00	Fallow	Pasture 42·95	Pasture 53·32	Pasture 45·85

3. INFLUENCE OF PASTURES AND FORAGE CROPS ON THE YIELD OF WHEAT GROWN IN ROTATIONS OF VARYING DURATION (continued).

Yields of peas and pasture on oven-dry basis.

Rotation	*Fallow, wheat* (bush. per ac.)		*Peas (grazed), wheat* (Peas, cwt. dry per ac.; Wheat, bush per ac.)		*Pasture, pasture, fallow, wheat* (Pasture, cwt. dry per ac.; Wheat, bush per ac.)		*Pasture, pasture, pasture, wheat* (Pasture, cwt. dry per ac.; Wheat, bush per ac.)	
	Commenced	Commenced	Commenced	Commenced	Commenced	Commenced	Commenced	Commenced
Year of harvest	1947	1948	1947	1948	1947	1948	1947	1948
1950	Wheat 15·32	Fallow	Wheat 12·79	Peas 11·72	Wheat 42·26	Fallow	Wheat 38·13	Pasture 51·61
1951	Fallow	Wheat 20·84	Peas 59·08	Wheat 17·89	Pasture 25·72	Wheat 28·47	Pasture 15·51	Wheat 21·29
Mean yield of wheat per ac. per annum (bush.)	24·55		24·55		35·37		29·71	
Mean yield of peas per ac. per annum (cwt. dry)	—		39·48		—		—	
Mean yield of pasture per ac. per annum (cwt. dry)	—		—		45·93		49·30	
Return per ac. over 4 yrs.								
(a) Wheat (bush.)	49·10		49·10		35·37		29·71	
(b) Grazing (cwt. dry)								
(i) Peas	—		78·96		—		—	
(ii) Pasture	—		—		91·86		147·90	
Gains in 4 years								
1. Over Fallow-wheat	—		78·96 cwt. peas		— 13·73 bush. wheat + 91·86 cwt. pasture		— 19·39 bush. wheat + 147·90 cwt. pasture	
2. Over Peas-wheat	—		—		— 13·73 bush. wheat + 12·90 cwt. pasture		— 19·39 bush. wheat + 68·94 cwt. pasture	
3. Over Pasture-pasture-fallow-wheat	—		—		—		— 5·66 bush. wheat + 56·04 cwt. pasture	
Long-term pasture	**1947**	**1948**	**1949**	**1950**	**1951**			
(cwt. dry per acre)	34·69	72·87	45·62	53·70	112·40			
	Av. 63·85 cwt. = 6 sheep per acre							

(i) Peas-wheat superior to Fallow-wheat.

(ii) Peas-wheat superior to Pasture-pasture-fallow-wheat.

(iii) Pasture-pasture-pasture-wheat superior to Pasture-pasture-fallow-wheat and to peas-wheat. (Take-all arising from Barley grass)

4. INFLUENCE OF TOP DRESSING ON THE YIELD AND CARRYING CAPACITY OF NATURAL PASTURE, 1925-1951.

Investigation commenced in 1925 on unimproved natural grassland dominated by *Danthonia* spp.

Manurial treatments:

A. Superphosphate, 185 lb. (40 lb. P_2O_5) per acre.

B. Superphosphate, 185 lb., and nitrate of soda, 78 lb. (12½ lb. N) per acre.

C. Nil.

D. Ground rock phosphate, 103 lb. (40 lb. P_2O_5) per acre.

E. Basic slag, 260 lb. (40 lb. P_2O_5) per acre.

Design: Unreplicated, single plot for each manurial treatment.

Area of plot: $^{13}/_{15}$ acre subdivided into 4 equal sections grazed in rotation by Merino wethers.

Total yield in cwt. air-dry herbage per acre.

	Treatment.					
Year	A	B	C	D	E	Mean A-E
1925	27·74	30·69	21·76	18·57	25·49	24·85
1926	43·20	43·57	28·35	27·16	49·15	38·29
1927	28·54	27·95	18·00	15·95	24·84	23·06
1928	39·63	41·81	24·31	27·89	35·58	33·84
1929	33·70	37·45	17·69	25·63	35·31	29·96
1930	30·32	39·86	20·67	30·56	43·56	32·99
1931	47·50	63·12	41·43	52·60	58·06	52·54
1932	75·66	81·11	56·92	70·34	78·25	72·46
1933	64·70	63·58	51·43	61·72	57·61	59·81
1934	38·00	52·44	20·23	43·66	48·67	40·60
1935	72·90	70·90	41·49	58·25	62·72	61·25
1936	42·24	48·67	29·54	47·30	41·15	41·78
1937	51·69	59·09	36·21	59·48	61·07	53·51
1938	54·47	57·62	34·92	60·11	64·06	54·24
1939	50·57	66·37	48·97	63·36	62·40	58·33
1940	26·48	30·30	29·48	33·86	28·41	29·71
1941	37·04	42·83	35·64	46·32	43·77	41·12
1942	54·74	70·14	45·17	66·08	65·26	60·28
1943	63·43	65·60	56·34	58·66	81·30	65·07
1944	44·43	47·80	35·95	54·59	51·54	46·86
1945	50·88	54·48	39·67	59·42	60·80	53·05
1946	66·24	60·46	56·18	71·32	69·96	64·83
1947	62·88	64·22	45·48	63·62	72·90	61·82
1948	67·73	82·37	55·32	101·98	96·65	80·81
1949	71·20	92·49	45·75	84·14	92·13	77·14
1950	63·60	79·21	36·08	88·62	92·02	71·91
1951	74·53	106·60	50·42	108·09	105·55	89·04
Mean 1925-51	51·26	58·55	37·90	55·53	59·56	52·56

Yield of legumes in the pasture, cwt. air-dry herbage per acre.

	Treatment.					
Year	A	B	C	D	E	Mean A-E
1925	20·25	18·35	6·57	5·64	14·35	13·03
1926	20·17	16·66	9·49	9·18	19·12	14·92
1927	4·29	0·40	1·02	0·44	2·43	1·72
1928	23·00	13·78	0·90	3·81	4·28	9·15
1929	14·45	8·24	2·18	4·74	13·30	8·58
1930	1·71	0·54	0·39	1·57	1·63	1·17
1931	6·80	2·79	3·56	5·33	5·18	4·73
1932	9·35	7·33	9·94	18·01	12·58	11·44
1933	5·40	2·23	4·20	4·24	3·10	3·83
1934	1·89	1·17	2·34	1·95	0·06	1·48
1935	44·53	27·97	10·14	20·69	18·63	24·39
1936	7·84	14·89	8·82	15·08	9·95	11·32
1937	19·30	15·15	9·69	14·63	31·34	18·02
1938	14·31	4·40	6·83	17·50	15·85	11·78
1939	6·85	4·13	12·73	17·73	11·26	10·54
1940	5·48	4·43	3·16	1·83	3·37	3·65
1941	9·73	3·62	2·54	1·45	2·06	3·88
1942	2·58	3·40	3·37	1·45	3·00	2·76
1943	7·80	11·05	6·04	5·82	14·27	9·00
1944	1·37	0·55	3·52	7·24	1·65	2·87
1945	16·98	17·69	4·95	2·18	8·79	10·12
1946	14·12	4·44	10·11	15·53	8·48	10·54
1947	29·98	22·25	13·98	26·58	25·35	23·63
1948	6·68	3·15	17·69	30·23	11·00	13·75
1949	29·22	35·41	8·34	22·73	25·19	24·18
1950	7·98	7·93	15·37	24·69	17·72	14·74
1951	2·04	1·69	15·68	8·49	5·15	6·61
Mean 1925-51	**12·37**	**9·39**	**7·17**	**10·69**	**10·71**	**10·07**

Stock-carrying capacity. Sheep days of grazing per acre.

	Treatment.				
Year	A	B	C	D	E
Mean 1928-49	1605	1765	1125	1598	1720
1950	1846	2057	1025	2049	2154
1951	2039	2804	1537	2589	2708
Mean 1928-51	1633	1820	1138	1658	1779

5. WHEAT VARIETY TRIALS, WAITE INSTITUTE, 1950.

I. *Late Varieties.*

	Mean Yield (bush./acre)
Quadrat	41·5
Pinnacle	41·3
(Kenya × Ghurka) × (Gluyas × Hope) × Ghurka × Ghurka (43-62)	38·0
Seewari 48	36·7
Diadem	35·6
Panther	31·2

Differences between two means of 2·6 bush./acre are significant at a 5 per cent. level of probability.

II. *Mid-season Varieties.*

	Mean Yield (bush./acre)
Insignia 49	34·0
Ridley 48	32·6
Javelin 48	32·2
Glenwari	29·8
Kendee	29·5
Dundee 48	29·1
Warigo	28·4

Differences not significant.

III. *Early varieties.*

	Mean Yield (bush./acre)
Gluyas × Hope × Ranee × Ranee (42-79)	34·0
Insignia 49	33·1
Insignia	33·0
Kenya × 4 Federation (2730)	29·3
Gabo	25·6
White Federation 45	24·9

Differences between two means of 2·1 bush./acre are significant at a 5 per cent. level of probability.

6. WHEAT VARIETY TRIALS, WAITE INSTITUTE, 1951.

I. *Mid-season Varieties.*

	Mean Yield (bush./acre)
Insignia 49	50·4
Javelin 48	43·4
Glenwari	42·2
Warigo	41·6
Dundee 48	40·7
Ridley 48	39·0
Kendee	36·0

Differences between two means of 3·39 bush./acre are significant at 5 per cent. level of probability.

II. *Early Varieties.*

	Mean Yield (bush./acre)
Insignia 49	52·8
Gabo	50·0
Gabo × 3 Dirk (726)	49·0
(Gluyas × Hope) × Ranee × Ranee (42-79)	47·0
Kenya × 4 Federation (2730)	45·4
Dirk 48	43·1
Orfed × 3 Dirk 48 (209)	42·3
White Federation 45	38·1

Differences between two means of 2·47 bush./acre are significant at 5 per cent. level of probability.

7. WHEAT VARIETY TRIAL, SADDLEWORTH, 1950.

Variety	Mean Yield (bush./acre)
Gabo × 3 Dirk (726)	31·4
Insignia 49	30·8
Orfed × 3 Dirk 48 (209)	30·1
Dirk 48	30·0
Kendee	27·1
Warigo	27·0
Panther	23·4
Seewari	23·0
Quadrat	22·7
(Kenya × Ghurka) × (Gluyas × Hope) × Ghurka × Ghurka (43-62)	22·4
R.A.C. 123	16·2

Differences between two means of 1·5 bush./acre are significant at a 5 per cent. level of probability.

8. WHEAT VARIETY TRIAL, SADDLEWORTH, 1951.

Variety	Mean Yield (bush./acre)
Quadrat	41·0
Insignia 49	39·6
Gabo × 3 Dirk (726)	37·8
Dirk 48	37·6
Kendee	36·4
Warigo	35·9
Seewari 48	34·6
Orfed × 3 Dirk (209)*	33·1
Panther*	29·0

Differences between two means of 1·8 bush./acre are significant at 5 per cent. level of probability.

* Pickled with copper carbonate, the remainder pickled with Ceresan.

9. LINSEED VARIETY TRIAL, WAITE INSTITUTE, 1950.

Variety	Days to Flowering	Yield in lb./acre	Oil content per cent. fresh weight	Iodine Number
Punjab 5	103	1512	42·7	187
Punjab C.1.20	101	1384	41·7	187
Punjab 23	98	1308	42·7	187
Punjab 47 C.1.1115	100	1148	42·7	187
Sheyenne C.1.1073	112	1308	40·8	192
3046 B	104	1168	43·7	193
Dakota C.1.1071	110	1164	39·8	198
Walsh	111	1044	41·7	189
Punjab × Walsh	103	951	41·7	185
Minerva C.1.1081	115	927	42·7	196
Crystal C.1.982	112	861	40·3	197

Design: Randomized blocks in four replications.

Date of sowing: 8th June, 1950.

Date of Harvesting: 16th-24th November, 1950.

Plot size: 3 rows 12′ × 12″—the middle row only used for yield measurement.

Diseases: Pasmo, rust, and collapse of the stem base.

Differences between two means of 171·4 lb./acre are significant at 5 per cent. level.

10. LINSEED YIELD TRIAL, WAITE INSTITUTE, 1951.

Variety or Strain	Days to Flowering	Yields in lb./acre	Oil Content per cent. dry basis	Iodine Number
Walsh	130	466	44·5	192
Aq. 279—C.P.I. 8127-T5	121	696	47·0	190
Aq. 280—C.P.I. 8128-T8	121	733	47·5	191
Aq. 282—C.P.I. 8139-	121	777	47·0	190
Punjab 5	122	774	47·5	195
Punjab C.I. /20	125	700	45·0	194
Punjab 23	111	530	48·0	191
Shayenne C.I. 1073	130	622	42·5	189
Dakota C.I. 1071	129	496	42·0	195
3046 B	127	512	46·5	189
Stock 18	122	488	46·5	191
27	125	688	46·5	196
28	123	396	45·0	192
30	118	552	49·0	187
53	122	500	46·0	191
58	124	596	45·0	190
60	122	531	45·0	188
65	121	551	46·0	187
66	125	574	43·5	188
68	124	505	44·0	189
69	123	689	45·5	194
70	121	588	44·5	187
71	125	617	44·0	184
72	124	472	44·0	188
76	121	547	44·5	189
78	116	529	45·5	190
80	122	506	45·5	192
89	127	632	45·0	185
92	121	648	47·5	189
98	123	550	44·5	187

Design: Randomized blocks in five replications.

Sowing Date: 29th May, 1951.

Harvest Date: 3rd and 4th December, 1951.

Plot Size: 12′ × 12″ rows.

L.S.D. of two means is 15·1 lb./acre at 5 per cent. level of probability.

11. SAFFLOWER ROD ROW TRIAL, WAITE INSTITUTE, 1950.

Variety or Selection	Mean Yield in lb./acre	Oil Content per cent. fresh weight	Iodine Number
Niphad 630	1843	26·9	148
Niphad 630	1781	27·8	146
67	1479	35·6	145
13	2054	33·8	145
11	1459	35·4	146
55	992	38·2	142
24	1649	36·1	148
23	2625	33·3	149
60	1762	31·9	147
18	1511	34·7	144
21	2147	34·6	148
7	1924	34·6	149
68	1774	30·8	147
40	1570	35·0	147
42	1633	35·8	148
44	1236	36·0	147
46	1568	35·0	146
28	1900	29·7	149
29	1394	30·2	148
30	1552	29·2	147
4	1856	34·9	148
52	1325	30·2	148
62	1743	31·1	147
64	1192	28·3	147

Location: Education Block, Waite Institute.

Design: Randomized blocks in four replications.

Date of Sowing: 13th June, 1950.

Date of Flowering: Niphad 27th November; all others from 1st to 8th December.

Superphosphate: 1 cwt./acre.

Differences between two mean yields of 151·5 lb. are significant at a 5 per cent. level of probability.

Commonwealth Scientific and Industrial Research Organization

Staff with Headquarters at the Waite Agricultural Research Institute (as at 31st December, 1951):

DIVISION OF SOILS:

Chief: J. K. TAYLOR, B.A., M.Sc., B.Sc. (Agr.).
Technical Secretary: A. L. C. DAVIDSON, Ph.D.(Agric.Chem.) (London).

Soil Physics Section:

Senior Principal Research Officer: T. J. MARSHALL, M.Ag.Sc., Ph.D.
Senior Research Officer: G. D. AITCHISON, B.E.
Research Officers: K. NORRISH, M.Sc. (overseas), J. P. QUIRK, B.Sc.(Agr.) (overseas), C. G. GURR, B.Sc., D. S. MCINTYRE, M.Sc., J. W. HOLMES, B.Sc., E. W. RADOSLOVICH, B.Sc.
Technical Officer: A. W. PALM.
Technical Assistants: N. W. FORRESTER, M. W. HUGHES.
Assistants: F. R. PEDLER, K. J. BARROW, L. A. G. AYLMORE, J. G. PICKERING.

Soil Chemistry Section:

Senior Research Chemist: C. S. PIPER, D.Sc. (part time).
Senior Research Officer: A. C. OERTEL (spectrography), M.Sc.
Research Officers: J. T. HUTTON, B.Sc., H. C. T. STACE, B.Sc., B. M. TUCKER, B.Sc., R. S. BECKWITH, B.Sc., M. RAUPACH, B.Sc.
Technical Officers: A. R. P. CLARKE, A. D. HALDANE, B.Sc., R. M. MCKENZIE.
Assistants: FILICIA J. A. DOE, JANET R. WYLIE.

Soil Survey and Pedology Section:

Senior Principal Research Officer: C. G. STEPHENS, D.Sc.
Research Officers: K. H. NORTHCOTE, B.Ag.Sc., G. B. BLACKBURN, B.Ag.Sc., E. A. JACKSON, B.Ag.Sc., W. H. LITCHFIELD, B.Sc. (Agr.), J. LOVEDAY, B.Ag.Sc., C. B. WELLS, B.Ag.Sc.
Cartographer: P. D. HOOPER.
Draughtsmen: M. C. COULLS, M. J. SPOONER.

Note: There are five Regional Centres—Brisbane, Hobart, Perth, Canberra, and Deniliquin—permanently staffed with research officers of the Soil Survey, Soil Chemistry and Soil Physics Section.

Soil Microbiology Section:

Research Officer: J. R. HARRIS, B.Sc.
Assistant: BAYES LLOYD.

Oil Seeds Investigations:

Research Officer (Chemist): R. E. SHAPTER, A.A.C.I.

COMMITTEE ON OENOLOGICAL RESEARCH:

(Chairman: PROFESSOR J. A. PRESCOTT, C.B.E., D.Sc., F.R.S.)
Senior Research Officer: J. C. M. FORNACHON, M.Sc., B.Ag.Sc.
Research Officer: B. C. RANKINE, B.Sc.
Assistant: NADIA H. BRESSLER.

DIVISION OF PLANT INDUSTRY:

Principal Plant Physiologist: L. A. T. BALLARD, Ph.D., M.A., M.Ag.Sc.
Research Officer: D. J. DAVID, B.Sc.

FIELD STATION: Division of Biochemistry and General Nutrition:

Technical Assistant: E. TALBOT-SMITH.

C.S.I.R.O. OFFICERS WHO HAVE LEFT FOR OTHER APPOINTMENTS SINCE 1ST JANUARY, 1949:

R. M. TAVENDER, MARGARET P. READ.

Commonwealth Scientific and Industrial Research Organization

Division of Soils

1. INTRODUCTION.

The Division of Soils of the Commonwealth Scientific and Industrial Research Organization has its headquarters at the Waite Agricultural Research Institute, and the relationship of the two bodies has continued as a closely linked association with mutual advantage. While the central organization of the Division has continued at an even level, the operations have extended considerably and it has consolidated its position in regional establishments at Brisbane, Canberra, Deniliquin, Hobart and Perth, at three of which active laboratories have been equipped.

The policy of regionalization of a large organization for soil research throughout Australia is very sound and has enabled a widespread attack on applied problems and extensive soil surveys. At headquarters much of the work has been on the more fundamental side.

Steady progress has been made with field and laboratory work towards the objective of studying the soil resources of Australia. One immediate and pressing problem has been the evaluation of new areas for land settlement by servicemen and latterly for civilian farmers also. In South Australia a large proportion of the survey work in the past two years has gone to this end.

The staff has grown slowly in the regional centres and an attempt has been made to encourage complementary work in soil surveys by State organizations which it is hoped may undertake wider responsibilities for it. Collaboration has been continued with certain C.S.I.R.O. bodies, particularly Land Research and Regional Survey Section, for whom all analytical work on soil samples and all soil mapping required on surveys is carried out. One officer is permanently on surveys associated with a field party of this Section. Close touch has been maintained with State and Commonwealth Departments interested in development in South Australia and a number of surveys conducted for them.

The development of soil mechanics research as a portion of the activities of the Soil Physics Section of the Division, has been notable, especially in relation to foundation engineering and the soils of Adelaide and Melbourne. It may now be said that not only engineers, but architects and the people at large concerned with building, have a lively interest in these problems of soils and foundations. The move from the practical advisory side to investigation of the basic aspects of soil problems in this field, will follow as a means of understanding the mechanics of soil movements under varying moisture conditions.

2. SOIL SURVEY AND PEDOLOGY.

Work in this section has comprised both routine soil surveys and fundamental pedological investigations. Staffing problems, including the loss of some experienced surveyors during the two years, have limited the number of projects undertaken. Nevertheless, work has proceeded on a total of 23 surveys throughout the Commonwealth, covering areas from 4 to 80,000 square miles in extent. Of these, 6 units totalling 1,290 square miles were in South Australia.

Compilation of a manual of Australian soils has been brought close to completion. This manual aims to provide a guide to the identification of the Great Soil Groups recognized in Australia and is for the use of workers in numerous organizations concerned with soils and land use.

South Australia.

The survey of a further area on Kangaroo Island was completed, making a total of 250,000 acres mapped by the Division on the Island. A sound system of classification and correlation of soil types with potential land uses has been laid down and the problems facing development, defined for investigation. By an arrangement the further extension of surveys has been undertaken by a State Department officer under the guidance of one of the Division's experienced surveyors. This has proved a useful collaboration and a further unit of virgin country has since been mapped. The surveys have laid the basic foundation for the study of the nutritional problems of crops and pastures on the newly developed areas on Kangaroo Island. It would appear, despite deficiencies in soil fertility, that the greater part of the area can be utilized for settlement, the problem portions having been defined and excluded from development.

The extension of mapping over 600 square miles of the Upper South-East has proceeded, linking on with a survey made 20 years previously by the Division near Keith. The present area extends as a strip of four Hundreds—Stirling, Cannawigra, Pendleton and Senior—from Keith to the Victorian border. It includes a large area of the land under development by the A.M.P. Society scheme. Although many assumptions have been made of potential development following successful experiments by C.S.I.R.O. Division of Biochemistry, it is now apparent that there is considerable soil variability, and a cautious approach with discrimination is needed for large areas with soils that have adverse profile features and potential salinity. Wind erosion is also a possibility in parts.

A survey of 230 square miles in the Kingston-Lucindale district in the South-East has been completed. Considerable problems in drainage control, salinity and soil infertility face any development of this area. The survey defined the soils, and their classification, with their land use relationships and problems.

The Barossa district survey has been begun and carried over about 20,000 acres in close detail in the Nuriootpa centre. There is a very complex formation of soils with many local problems in land use, especially concerning the association of soils and horticultural crops. Difficulties and correct procedure in reconstruction of farm lands following decline of old tree and vine plantings are being examined in regard to economic land utilization. This area is exceedingly interesting from the pedological standpoint. The soil groupings and origin have been the subject of close study.

Small unit areas at Cooltong near Renmark and near Loxton have been mapped in detail to determine their usefulness for irrigation of horticultural crops. The soil types are well known as to their value in this regard and utilization maps were prepared and followed in design of additional areas for planting.

Other Parts of Australia.

Surveys have been carried on throughout the Commonwealth, including North Australia, during 1950-51. Major work has been divided between all the States except Victoria, where operations have been only at the reconnaissance level over limited areas. Some of the importants units are Burdekin Valley in North Queensland, the Southern Tablelands, parts of the Riverina and the Macquarie Region in N.S.W., the Launceston Basin in Tasmania, the Albany district in W.A., and the Ord-Victoria River Region of North Australia. These have aggregated 72,870 square miles, of which 24,420 square miles are in some degree of detail, and the remainder as broad scale reconnaissance mapping up to the Great Soil Group level.

3. SOIL CHEMISTRY.

A wide range of projects and research has been carried on in 1950-51 with a fair proportion of a fundamental nature. As usual, considerable assistance has been given to the pedologist's problems arising during soil surveys, not only in routine analysis but in investigations of a detailed chemical type such as on the samples from Lismore, N.S.W., which were thoroughly characterized as members of the Krasnozem group.

Ion Exchange and pH Investigation.

Work has proceeded on a study of ion exchange and pH relationships of various cation-dominant soils chosen with special regard to the nature of the predominant clay mineral present. Bulk samples of the soils have been prepared by suitable leaching treatment to yield material dominant in calcium, magnesium, potassium, sodium and hydrogen ions. The examination of the prepared soils and mixtures of them has begun and at the same time techniques are being devised such as for the determination of total exchange capacity in small samples of soils. It has been found that the potential at the potassium-chloride bridge of the reference electrode may reach sizable proportions under certain conditions of contact of the colloid suspension with the potassium-chloride solution of the junction. The work is designed to improve knowledge and interpretation of soil pH readings as a routine procedure.

Copper and Manganese Availability.

The mechanism of fixation and release of copper and manganese in the soil has been further studied with the object of discovering the availability of these elements in soil and their effect by interaction. The fixation of copper and manganese in the surface half-inch of soil when they were applied as a surface dressing, points to the necessity for even distribution in cultures to assess their effect on growing plants. With oats in pot experiments the addition of up to 100 lb. copper sulphate per acre brought about a lowering of manganese uptake,

but very heavy applications actually increased the manganese taken in by the plants in two soils. The extractants which may be used for fractionating manganese in soil are the subject of current research.

Terra Rossa and Rendzina Soils.

Terra Rossa and Rendzina soils are morphologically different formations on similar calcareous parent material under identical climatic conditions and occur in close proximity to each other. Chemical work, with which certain X-ray studies were associated, was continued with particular reference to the free ferric oxide present. So far no solution to the problem has been found on chemical grounds and the examination is to proceed from the inorganic to the organic fraction.

pH Variability in Field Samples.

Detailed investigation of spatial and seasonal variations in pH of standard soil types under field conditions has been completed at two station—Barooga, N.S.W., and at the Waite Research Institute. At both sites, spatial variations over very short ranges were noteworthy but seasonal variations were not significant at Barooga and slight, but detectable, at Adelaide. In the latter case the rise occurred with the opening rains in April and declined slowly to a minimum from mid-summer to autumn. At Adelaide the variation spatially could be correlated with differences in exchange capacity but not at Barooga generally. This investigation led to the research on pH and ion exchange mentioned above.

Basaltic Soils at Lismore, N.S.W.

The chemical examination of red and black basaltic soils which had been surveyed and described in detail over an area of 400 square miles at Lismore, N.S.W., was carried through to define the characteristics of the two groups. The fractionation of calcium, magnesium, potassium, sodium and strontium in the surface soils indicates some of the differences between the various soil series defined in the soil survey. Generally half of the total calcium is present in an exchangeable and presumably available form.

Spectrochemical Investigations.

Considerable progress has been made in spectrochemical techniques for analysing soil and plant material. Many elements of pedological or biological interest occur in extremely low concentrations which may escape detection. The techniques for concentrating such elements in a single operation are being examined. The effects of excess potassium sulphate and excess calcium sulphate on the emission of radiation from copper, molybdenum, tin and manganese were studied and potassium sulphate appeared satisfactory as a spectrographic buffer. However, subsequent work showed that its buffering effect was not sufficient to overcome the big differences in composition in the minor components between different plant species.

Difficulties encountered in the accurate determination of manganese in plant ash were found to be due to pronounced self-absorption of the analysis line. An equation has now been developed which fits the experimental results satisfactorily over a tenfold range of concentrations of manganese.

In many aspects of spectrographic work the application of statistical methods has proved valuable and the use has been extended. Attention has been given to the frequency distribution and other statistical values of the error which occurs in spectrographic analysis of soil and plant ash material when D.C. arc excitation is used.

The quantitative distribution of several of the less common metallic elements in soil profiles selected as representative of Great Soil Groups in South Australia has been further studied.

Special Analytical Methods.

A satisfactory method has been developed for determining the free iron oxide in soils. The method was used extensively in the analysis of the basaltic soils of the Lismore survey mentioned above. Work has also begun on the possibility of simultaneous estimation of calcium, magnesium, sodium and potassium by direct measurement of the emission lines from the flame spectrograph by photomultiplier tubes. The principle has been worked on at the Macaulay Institute, Scotland. The findings are that the method is feasible but practical difficulties are great.

An improved mixed indicator was also developed for rapid colorimetric pH determinations in the field. The usual routine analysis of all samples collected by soil survey parties operating from Adelaide and in North Australia has gone on and certain measurements made for the regional laboratories with special equipment available.

4. SOIL PHYSICS, MECHANICS AND MINERALOGY.

The range of activity of this section covers normal physical characteristics of soils, engineering properties, and the mineralogy of the clay fraction. A commencement has been made with an aspect of soil erosion concerning damage to the soil surface by rain.

Soil Structure.

Earlier work showed that structural aggregation could be studied by a drop-shatter technique. This has now been applied to experimental material from irrigation areas in N.S.W. where structure is related to water infiltration and to soils under pasture and cultivation at the Waite Institute. Even one year of pasture in a rotation produced larger aggregates under this treatment than crop alone. Techniques for examining structural state have been covered, both by wet sieving under water and dry sieving. The disaggregating effect of entrapped air on moistening clods has been shown to be significant and breakdown related to initial water content of the soil mass before wetting.

Water Movement.

Arising from extensive infiltration measurements using the ring method, in various areas where irrigation is involved, the effect of lateral movement of water upon the total absorption has been analysed. The size of the plot or ring used for experiment has a strong influence. The minimum infiltration capacity of a given soil varied inversely with the fraction of applied water remaining directly under the plot at the conclusion of the trial. Using this

fraction as a correction factor, small plots may be compared with larger ones and variabilities between replicates could be reduced.

The tendency of water to move under a temperature gradient was examined. In a closed system there is a movement of vapour from the warm to the cool end and a backward movement of liquid towards the warm end. Certain features of these changes are obscure and the mechanism of vapour flow is being studied with respect to diffusion rates in soils under a temperature gradient. Measurement of water flow is marked by redistribution of soluble salts whose altered concentration indicates the flow having taken place. The experimental work has all been done at relatively low moisture contents, and points to conditions of salt movement in the natural soil not previously understood.

Damage of Soil by Rain.

Impact of rain on the soil surface may cause compaction of the immediate surface layer and may affect the cultivation zone in a very wet winter. Field experiments showed that the bulk density of soil under a wheat crop in wheat-fallow rotation was greater than under a four-course rotation with peas and pasture.

Seasonal Moisture and Volume Changes.

In connection with stability of structures, both pavings and buildings, studies have been made on seasonal moisture changes both in exposed and covered locations. Downward movement has been followed with gypsum block moisture meters and the amount of stored water at the various depths calculated for Adelaide soils. Moisture changes occur seasonally over at least 10 feet under normal seasonal conditions in Adelaide. Measurements of soil water tensions under a sealed roadway have been measured to assess the soil moisture regime under Adelaide conditions for such structures.

Soil movements at different depths with changing moisture status of the profile have been measured through a further period and correlations sought between volume and moisture changes. The mechanism of this relationship is being sought also in laboratory experiments on the swelling-water content-tension relationship of clay materials. Volume changes of a remoulded clay material have been followed over a range of tensions greater than that encountered in the field.

Engineering Properties of Soils.

Further mapping of soils according to groups classified on their engineering properties has led to the production of a map for the Adelaide suburban area. It has been co-ordinated with geological features. The physical characteristics of the soil groups have been determined and the way is clear for sounder advisory service to be given. Considerable advice is already made available to enquirers for Adelaide conditions. A mobile laboratory has been equipped in a caravan for testing soils on the spot to characterize the soil groups under wet winter and dry summer states and in all stages between.

Soil Colloids.

In 1950 considerable effort was concentrated on studies of the red brown earth soil group. An excellent range of samples from southern Australia provided the basis for the research and against these were set profiles from

Queensland and North Australia. Attempts were made to correlate variable swelling properties with clay mineral constitution. In southern Australia the clay fractions seem to be predominantly illite with kaolinite less important; the proportions vary between profiles, but are constant throughout any one profile. The Queensland samples have apparently much more kaolinite, and halloysite is the principal mineral. The work was tied in where possible with the swelling capacity of the clays and its relation to engineering properties of the soils.

In 1951 work began on the terra rossa and rendzina soils to endeavour to define mineralogical differences which might bear on the genesis of these two entirely different soil groups on calcareous parent material. The results so far are not conclusive and further work will be done on the iron oxides, of which magnetite and maghemite have been identified.

Work is continuing on the fluorescent X-ray spectrograph. A curved crystal focussing spectrograph has been built and proved satisfactory for rapid determinations of certain elements.

5. SOIL MICROBIOLOGY.

In 1950-51 a large proportion of the work was transferred to field trials to test out ideas from previous glasshouse experiments and observe the activity and persistence of *Rhizobium* in virgin soils of low fertility status. Plots were set out with some assistance from State bodies at Parndana, Kangaroo Island, and at Lucindale and Keith in the Upper South-East. It has been found that a wide range of fungi indigenous in the soils are able under certain conditions to invade the root tissues and set up chronic infection. If environmental or nutritional stresses develop in the plant, such infection may prove adverse. Unduly dry soil conditions at certain periods, frosts or temporary water-logging will contribute to decline for this reason. The principal nutritional problem is deficiency of phosphorus and, less commonly, nitrogen. The infections then may become systemic parasites and the end result is either failure to grow and set seed or extensive root-rot.

It is interesting to note that members of the genus *Rhizobium* appear to be indigenous to a wide range of poor soils in South Australia. Effective nitrogen-fixing and ineffective types have been isolated. Subterranean clover has sub-optimal nodulation in the first year but by the end of the growing season the plants are not suffering from nitrogen lack. Inoculated strains of highly effective character by glasshouse tests may fail in competition with indigenous Rhizobia or may not persist to the second season.

A range of Rhizobia have been isolated from native legumes, and additional genera examined are *Daviesia, Viminaria, Gompholobium, Eutaxia* and *Swainsona.* Their cross-inoculation characteristics ally them with the cow pea group, and tests against other groups have failed. Hence, the indigenous Rhizobia in virgin soils governing the above investigations do not appear to be associated with native legumes.

Serological testing of several hundred isolates of *Rhizobium* from subterranean clover has been carried on to determine antigenic relationships. A wide range of antigenic types of diverse distribution has been found with little definite locality relationship.

A Soil Map of the Waite Institute

A soil map of the Waite Institute property has been prepared as the result of a soil survey carried out by the Division of Soils, C.S.I.R.O., during 1950.*

The survey has shown that the soil pattern over the property is a fairly complex one and that the considerable diversity in the number and characteristics of the Soil Types seems to be a reflection of marked contrasts in the relief and water relations rather than in the parent material which is mainly silty to siliceous Pre-Cambrian slates or their derived alluvium or colluvium.

The greater part of the property devoted to field experiments lies over an alluvial-colluvial apron and adjacent gentle slopes. The grazing areas, however, extend above the abrupt western escarpment of the Mount Lofty Range which forms part of an uplifted and dissected fault-block. The property continues eastwards to the crest of the Netherby Hill–Brown Hill ridge which forms a watershed between the short steep gorges along the escarpment and lateral gullies of the Brown Hill Creek gorge. The rainfall increases with altitude in an easterly direction across the property—from 22·3 ins. at Urrbrae Agricultural High School on the 300 ft. contour to approximately 30 ins. at the top of Netherby Hill, an elevation of over 1,100 feet.

Red Brown Earths with marked textural differentiation—into topsoil loam and subsoil clay—constitute the dominant soils below the scarp. Dark-coloured soils of fine texture, representing lime-enriched Black Earths and Wiesenboden soils, occur concurrently with the Red Brown Earths and are sharply differentiated from them in the soil pattern. Above the skeletal and near skeletal soils of the very steep escarpment slopes Pedocals are of rare occurrence and there is a transition from soils with brown topsoils to Podzolic soils with greyish topsoils. On the crest of the ridge there is evidence of lateritization of the basement rocks.

The soils have been classified according to morphological criteria.

The Mapping Categories.

Although the survey was of a detailed character, it was only found practicable to map certain of the soil types individually owing to the complexity of the soil pattern. The remainder of the mapping units represent groups of soils in which the component series have certain dominant morphological attributes in common or soil mosaics in which the component types show diverse characteristics.

A—1 and A—2: These categories indicate the occurrences of Red Brown Earths in the *Urrbrae Series*. The soils of both mapping units are essentially similar. The former (A—1) are free from waterworn gravels or stone and occur most characteristically on the even gentle slopes between disused distributary watercourses, while the latter (A—2) are associated with these disused watercourses or their buried gravelly beds.

The surface soil in the virgin or near virgin condition is a brown fine sandy loam with some distinct organic matter accumulation and passes through a rather compact and slightly bleached sub-surface soil to the red-brown clay

* See C.S.I.R.O. Division of Soils, Divisional Report, 2/51. This section has been prepared by W. H. Litchfield.

subsoil. The transition from A to B horizons, although marked, may be rather diffuse and is associated with the development of a granularity in the structure of the finer-textured soil. The lower part of the B_1 (clay) horizon usually shows prismatic structural development. Lime occurs in the deeper subsoil both in a soft form and in small hard nodular concretions. In these soils, the depth of the A horizon was found to vary between 8 and 22 inches but it usually lies between 10 and 15 inches. The depth to the B_2 (lime) horizon was found to vary between 27 and 72 inches but it lies usually between 33 and 40 inches. Greater depths of topsoil and depths to the B_2 horizon tend to be found in the stony or gravelly soils.

The soils of the *Urrbrae Series* are usually of slightly acid reaction in the A horizon, of neutral reaction in the B_1 horizon and of moderately alkaline reaction in the B_2 horizon. Calcium is the dominant exchangeable metal cation in both A and B horizons and soluble salts do not accumulate to any significant extent in the profile. Illite and kaolinite* are known to be conspicuous constituents in the colloidal fraction and ferric oxide accumulates in the B_1 horizon. It is known that spatial variability in profile characteristics as reaction and clay content may be pronounced over small distances in these soils.

In their uncleared state, these soils supported a savannah woodland of well-grown peppermint gum *(Eucalyptus odorata)*.

A—3: This category indicates the occurrences of shallower stony or gravelly Red Brown Earths on the moderate to steep colluvial slopes adjacent to the scarp. Some subdued yellowish mottling may be apparent in an otherwise red brown clay subsoil and large soft lime pockets in moderate to large amounts may be conspicuous from 18 to 30 inches. The depth of topsoil is variable depending largely on the degree of slope and was found to vary between 4 and 15 inches. These soils support well-grown *E. odorata*.

B—1: This category includes occurrences of Red Brown Earths on an alluvial-colluvial fan and adjacent disused distributory watercourses, drainage lines and closed depressions. Variable subdued yellowish mottling in the red brown clay subsoil is a weakly developed hydromorphic expression and an absence of lime from the deep subsoil may indicate locally intensified leaching. The topsoil, however, remains a brown colour and the subsoil may retain a prismatic structure. The soils are usually gravelly or stony and the depth of topsoil tends to be greater than in the *Urrbrae Series*, varying between 12 and 21 inches and usually between 14 and 18 inches. Lime when present was not encountered above 48 inches. These soils support well-grown *E. odorata, E. camaldulensis* (red gum) and *E. leucoxylon* (blue gum).

B—2: This category includes types lying adjacent to dark-coloured soils with pronounced textural contrast in the profile and usually with pronounced subsoil mottling. The sub-surface soil may be markedly bleached, indicating a degree of solodization and the clay subsoil may show reddish, greyish and sometimes yellowish mottling. The amount of gravel or stone in these soils may be small. The depth of the A horizon was found to vary between 9 and 20 inches. Lime occurs in the deeper subsoil, at depths varying between 24 and 36 inches.

C—1: This category indicates the occurrences of fine-textured and dark-coloured lime-enriched Black Earths and Wiesenboden soils of the *Claremont Group*. Under permanent pasture, these soils frequently develop a slight

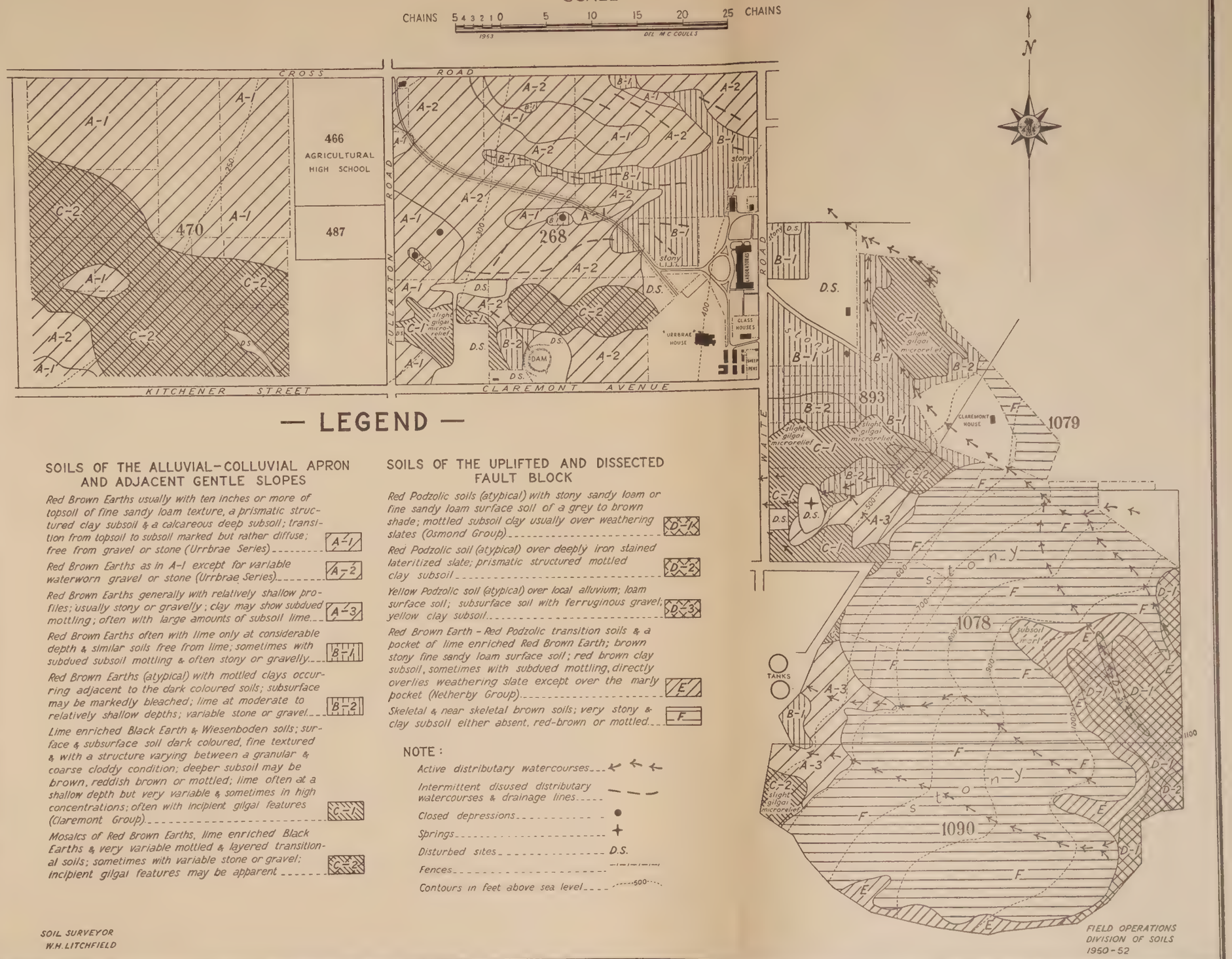
* These minerals have been identified in X-ray diffraction studies of E. W. Radoslovich.

SOIL MAP
WAITE AGRICULTURAL RESEARCH INSTITUTE
SECTIONS 268, 470, 893, 1078, 1090 AND PART SECTION 1079
HUNDRED OF ADELAIDE, S.A.

— SCALE —

CHAINS 5 4 3 2 1 0 5 10 15 20 25 CHAINS

1963 DEL M C COULLS



— LEGEND —

SOILS OF THE ALLUVIAL–COLLUVIAL APRON AND ADJACENT GENTLE SLOPES

- Red Brown Earths usually with ten inches or more of topsoil of fine sandy loam texture, a prismatic structured clay subsoil & a calcareous deep subsoil; transition from topsoil to subsoil marked but rather diffuse; free from gravel or stone (Urrbrae Series) — A-1
- Red Brown Earths as in A-1 except for variable waterworn gravel or stone (Urrbrae Series) — A-2
- Red Brown Earths generally with relatively shallow profiles; usually stony or gravelly; clay may show subdued mottling; often with large amounts of subsoil lime — A-3
- Red Brown Earths often with lime only at considerable depth & similar soils free from lime; sometimes with subdued subsoil mottling & often stony or gravelly — B-1
- Red Brown Earths (atypical) with mottled clays occurring adjacent to the dark coloured soils; subsurface may be markedly bleached; lime at moderate to relatively shallow depths; variable stone or gravel — B-2
- Lime enriched Black Earth & Wiesenboden soils; surface & subsurface soil dark coloured, fine textured & with a structure varying between a granular & coarse cloddy condition; deeper subsoil may be brown, reddish brown or mottled; lime often at a shallow depth but very variable & sometimes in high concentrations; often with incipient gilgai features (Claremont Group) — C-1
- Mosaics of Red Brown Earths, lime enriched Black Earths & very variable mottled & layered transitional soils; sometimes with variable stone or gravel; incipient gilgai features may be apparent — C-2

SOILS OF THE UPLIFTED AND DISSECTED FAULT BLOCK

- Red Podzolic soils (atypical) with stony sandy loam or fine sandy loam surface soil of a grey to brown shade; mottled subsoil clay usually over weathering slates (Osmond Group) — D-1
- Red Podzolic soil (atypical) over deeply iron stained lateritized slate; prismatic structured mottled clay subsoil — D-2
- Yellow Podzolic soil (atypical) over local alluvium; loam surface soil; subsurface soil with ferruginous gravel; yellow clay subsoil — D-3
- Red Brown Earth – Red Podzolic transition soils & a pocket of lime enriched Red Brown Earth; brown stony fine sandy loam surface soil; red brown clay subsoil, sometimes with subdued mottling, directly overlies weathering slate except over the marly pocket (Netherby Group) — E
- Skeletal & near skeletal brown soils; very stony & clay subsoil either absent, red-brown or mottled — F

NOTE:

- Active distributary watercourses
- Intermittent disused distributary watercourses & drainage lines
- Closed depressions
- Springs
- Disturbed sites — D.S.
- Fences
- Contours in feet above sea level — 500

SOIL SURVEYOR
W.H. LITCHFIELD

FIELD OPERATIONS
DIVISION OF SOILS
1950 – 52

gilgai microrelief associated with coarse cracking in dry surface soil. The deeper subsoil may be brown or reddish brown in the soils with black earth affinities or mottled with brownish, reddish, greyish or yellowish colours in the soils with Wiesenboden affinities. Organic matter enrichment in the form of staining, dark pockets or tapering inclusions may extend into the deeper subsoil, this being more pronounced in the Wiesenboden soils. Lime occurs in these soils in a diffuse or soft form and it is often present at or near the surface although in certain drainage lines there may be a moderate depth of soil free or nearly free from lime. Lime may occur in large amounts as marly accumulations.

The soils of the *Claremont Group* are of neutral to moderately alkaline reaction in the surface soil and of moderately to very strong alkaline reaction in the subsoil. Soluble salts may accumulate to a slight extent in the subsoil. The apparent organic matter content of the surface soil may be significantly greater than that of soils of the *Urrbrae Series.*

Two springs with telluric waters of alkaline reaction are situated in occurrences of these soils.

The soils support well-grown *E. odorata, E. camaldulensis* and *E. leucoxylon.*

C—2: This category indicates the occurrences of mosaics of brown and dark-coloured surface soils. The brown soils tend to show marked textural contrast in the profile and sometimes correspond to soils of the *Urrbrae Series* while the dark-coloured soils tend to be fine-textured and to correspond with soils of the *Claremont Group.* Gravels and stone may occur in these soils and variants are found with hydromorphic characteristics—as indicated by subsoil mottling and halomorphic features as indicated by strongly bleached sub-surface horizons or small accumulations of soluble salts in the subsoil which may be found in a very sticky state. Transition types with red-brown and dark colours in the subsoil as mottlings or in layers may be encountered. Slight gilgai microrelief formations may develop under permanent pasture. Although soil reaction and the presence of any salt accumulation apparently tends to follow the affinities of the individual types towards the *Urrbrae Series* or the *Claremont Group,* certain soils with pronounced textural contrasts were found with small salt accumulations in subsoils with a strongly alkaline reaction. The proportion of exchangeable magnesium ion and sodium ion may be significantly greater than in the *Urrbrae Series.* The depth to the B_2 horizon may be relatively shallow, lime being encountered between 18 and 36 inches.

D—1: This category indicates the occurrences of slightly hydromorphic Red Podzolic Soils of the *Osmond Group* on moderate to steep hillside slopes above the scarp. The surface soil is of a greyish to light brownish colour and the sub-surface soil may be distinctly bleached and may contain large amounts of only slightly weathered stone. The clay subsoil may be mottled with reddish, yellowish and sometimes greyish colours and usually passes into a C horizon with softish weathering slate from depths of about 24 inches. These soils may be slightly acid in reaction in the surface soil and the subsoil may also give an acid reaction. The soils support *E. odorata* and *E. leucoxylon,* the trees sometimes being of a rather stunted habit. *E. camaldulensis* occurs in certain apparently moister situations.

D—2: This category indicates the occurrence of a slightly hydromorphic Red Podzolic Soil restricted to a hill-crest. Deeply iron-stained detrital stone occurs over the shallow surface soil, which is greyish in colour and passes

abruptly into a coarsely prismatic structured clay, red brown and light grey brown on top and weakly mottled lower in the subsoil with reddish, greyish and yellowish colours. Some organic penetration along cleavages is evident. The clay passes into weathering slate, at first deeply iron-stained, but markedly bleached at greater depths. The surface soil is moderately acid in reaction and the subsoil slightly acid. The soil supports *E. leucoxylon* and *E. odorata* which are mostly stunted in appearance.

D—3: This category indicates the occurrence of a Yellow Podzolic Soil restricted to watercouse alluvium above the scarp. The surface soil is a deep loam with marked organic accumulation and the subsurface soil is rather bleached, contains ferruginous gravel and a perched seasonal water-table. It passes into a yellow clay—at about 22 inches in the centre of a drainage line. The soil supports well-grown *E. camaldulensis* and *E. odorata.*

E: This category is composed of soils of the *Netherby Group.* These are soils with brown stony medium-textured surface soils and red brown clay subsoils on moderate to steep slopes above the scarp. They are usually free from lime in the deeper subsoil, but reddish and yellowish mottling may appear in the clay above the weathering slate. Over the crest of one spur, a continuous marl appears in the subsoil at a depth of 12 to 18 inches. This soil is of neutral reaction in the A and B horizons and strongly alkaline in the B_2 horizon, while the soils which are free of lime appear to be neutral to slightly acid in reaction throughout.

These soils support well-grown *E. odorata* and *E. leucoxylon.*

F: This category includes the very stony skeletal and near-skeletal soils of the very steep scarp-front slopes, gorge sides and associated watercourses. Surface soils are mainly brown in colour and clay subsoils when present are either red-brown or mottled near the beds of watercourses. The soils support *E. odorata, E. leucoxylon, E. camaldulensis, Casuarina stricta* (She-oak) and occasionally *Pittosporum phillyreoides* (native willow), the latter two species occurring on the steepest and stoniest slopes. *E. odorata* dominates slopes with a northerly or westerly aspect while *E. camaldulensis* is restricted to southerly slopes and the beds of watercourses.

Oenological Research

Oenological research at the Waite Institute is conducted under a special Committee of the C.S.I.R.O. representative of the wine industry and the scientific disciplines concerned. It is financed in equal parts by the Australian Wine Board and the Federal Treasury.

1. Sherry Investigations.

The effects of various factors on the changes brought about in wine by the sherry flor yeasts and the relationship of these changes to the development of "flor character" in the wine have been further studied. In a vigorous flor film growing on wine, the upper portions of the film are exposed to the air, but many of the cells in the lower portions of the film are exposed to low oxygen tensions. Thus the changes brought about in the wine result from both aerobic and anaero-

bic metabolism of the flor film, and the accumulation of acetaldehyde and development of flavour and aroma have been found to depend on the balance between aerobic and anaerobic processes. The influence of many factors on this balance have now been ascertained, and recommendations based on these findings are being applied in the industry with promising results.

Some good quality flor sherries have been made in the laboratory by means of a percolation column packed with oak chips on which the flor yeast grows. However, after extensive tests it was decided that neither the quality of the product nor the economics of the process made the percolation column more attractive than the traditional cask process under industrial conditions.

2. Wine Yeasts.

Further strains of wine yeasts from both local and overseas sources have been added to the collection, and all strains have been tested in laboratory fermentation trials. From the results obtained it is apparent that the yeasts differ considerably in alcohol production, completeness of fermentation, and in tolerance of high temperatures. The investigations have also shown the desirability of developing improved techniques for testing the fermentation characteristics of yeasts in the laboratory and work is proceeding along these lines.

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